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Ningaloo Vision Operations Environment Plan WA-35 – L (Van Gogh/Coniston/Novara Fields)

PROJECT / FACILITY	Ningaloo Vision
REVIEW INTERVAL	60 Months
SAFETY CRITICAL DOCUMENT	NO

Rev	Owner	Reviewer/s *Managerial/Technical/Site*	Approver
10	Operations Superintendent – Oil Assets	HSE Team Lead – Production	Production Manager – NV

Any hard copy of this document, other than those identified above, are uncontrolled. Please refer to the Santos Business Management System for the latest revision.

Rev	Rev Date	Author	Amendment
10	16/12/20	Santos	• Issued to NOPSEMA • Response to NOPSEMA comments on OMR dated 23 September 2020
9	24/08/20	Santos	• Issued to NOPSEMA • Response to NOPSEMA comments on RFFWI dated 13 May 2020
8A	01/06/20	Santos	• Issued for Internal Santos Review • Response to NOPSEMA comments on RFFWI dated 13 May 2020.
8	24/03/20	Santos	• 5-year EP revision update
7.5	18/12/18	Quadrant Energy Limited	• Amendments to section 6.5.4 as result of MoC 102 to delete controls in Section 6.5 for planned PFW as it has its own section 6.7 for contingency PFW discharge. • Amendment to Section 6.5 (planned discharges) to include AFFF testing as per MOC-169; • Amendment to Section 6.8 (Contingency PFW Discharge) to describe ecotoxicology testing when Novara field brought online, as per MOC-170; • Amendment to Section 7.3.4 to amend wording around ballast water management in Australia Waters as per MOC-172; • Amendment to Section 7.7.5 to change the maintenance frequency of a piece of equipment, as per MOC-172; • Amendment to Section 6.3.4 to include the change of lightglobes on the FPSO, as per MOC-172; • Amendment to Sections 6.1.4, 6.2.4, 6.4.4, 6.5.4, 6.8.5, 7.1.4, 7.2.4, 7.3.4, 7.4.4, 7.7.5 for 21 administrative changes only (improved wording and use of correct terminology) as per MOC-172; • MoC 199 – changes to section 7.3.4 and 7.3.6 regarding IMS as a result of December 2017 NOPSEMA inspection • MoC 207 for subsea gas release and planned discharges resulting in amendment to section 6.5 and inclusion of Section 7.9 and amendment to reportable gas release in Section 9.1.2. • MoC 208 for subsea gas release resulting in the inclusion of Section 7.9

			• Updated the company name of Apache to Quadrant in text. • Updates to Government regulatory Department names as at 2018 (where the context is relevant). • Marine Order 3 – change to Marine order 70 as marine order 3 no longer exists. • Inclusion of updated Environment Policy • Change title of OSCP to updated Regulatory title of OPEP. • Inclusion (at the request of NOPSEMA) of reference to a damaged guidepost marker remaining on the seabed from the Novara drilling campaign in the same title in 2016 to Section 6.1.1 6.1.3, 6.1.4, 6.1.6. • Correction of the location diagram showing the operational area. The pink operational area as depicted on Figure 1-1 (and follow on figures) in previous versions has been incorrectly drafted as it doesn't capture all the subsea equipment as per the definition of an operational area outlined in Section 1.6 "operational area". This is a drafting correction. The spatial operational area has not changed. MoC 206 change to section 3.3 to allow for residual drill fluids to be brought back to the FPSO topsides.
7.4	02/02/16	Quadrant Energy Limited	Quadrant Energy rebadging and update to company description in Section 1.3
7.3	15/07/15	Apache Energy Ltd	Amendment of Table 7.3, inclusion of maximum production chemical volumes as per MOC 108
7.2	19/05/15	Apache Energy Ltd	Removal (strikethrough) of text in Section 6.5.4 as per MOC-102
7.1	5/05/15	Apache Energy Ltd	Incorporates changes as per NOPSEMA RFFWI on the NOPSEMA accepted Rev 7
7	18/03/15	Apache Energy Ltd	Revised to incorporate NOPSEMA comments on Rev 6
6	31/12/14	Apache Energy Ltd	Revised to incorporate contingency discharge of PFW and to reflect amended OPGGS(E) Regulations
5	19/03/14	Apache Energy Ltd	Revised to incorporate comments received on Rev 4 from NOPSEMA
4	24/12/13	Apache Energy Ltd	Revised to incorporate comments received on Rev 3 from NOPSEMA and SEWPaC
3	9/08/13	Apache Energy Ltd	Revised for changed Operator and 2009 OPGGS Regulations. Issued to NOPSEMA and SEWPaC

2	4 May 09	Apache Energy Ltd	Revised to include DEWHA comments
1	3 April 09	Apache Energy Ltd	Revised to include DEWHA, DMP and Stakeholder Consultation Group (SCG) comments
0	13 Jan 09	Apache Energy Ltd	Issued to DEWHA/DMP

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APPENDIX I – NV PW WATER AND SEDIMENT QUALITY MONITORING AND SAMPLING PLAN

Definitions

The following terms as used within this environment plan have definitions used in the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*:

Activity means a petroleum activity or a greenhouse gas activity.

Control measure means a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks.

Environment means:

a. ecosystems and their constituent parts, including people and communities;
b. natural and physical resources;
c. the qualities and characteristics of locations, places and areas;
d. the heritage value of places; and includes; and
e. the social, economic and cultural features of the matters mentioned in paragraphs a., b., c. and d.

Environmental impact means any change to the environment, whether adverse or beneficial, that wholly or partially results from an activity.

Environmental management system includes the responsibilities, practices, processes and resources used to manage the environmental aspects of an activity.

Environment Minister means the Minister administering section 1 of the EPBC Act.

Environmental performance means the performance of a titleholder in relation to the environmental performance outcomes and standards mentioned in an environment plan.

Environmental performance outcome means a measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks are of an acceptable level.

Environmental performance standard means a statement of the performance required of a control measure.

Environment plan means the document known as an environment plan that is submitted to the Regulator under regulation 9.

EPBC Act means the *Environment Protection and Biodiversity Conservation Act 1999.*

Facility includes a structure or installation of any kind.

Petroleum activity means operations or works in an offshore area undertaken for the purpose of:

a. exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or
b. discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act.

Petroleum titleholder means any of the following:

a. a petroleum exploration permittee;
b. a petroleum retention lessee;
c. a petroleum production licensee;
d. a pipeline licensee;

e. an infrastructure licensee;

f. the registered holder of a petroleum access authority;

g. the registered holder of a petroleum special prospecting authority;

h. the holder of a petroleum scientific investigation consent.

Produced formation water means natural aqueous fluid recovered from a petroleum reservoir in association with the petroleum.

Recordable incident, for an activity, means a breach of an environmental performance outcome or environmental performance standard, in the environment plan that applies to the activity that is not a reportable incident.

Regulator means:

a. in relation to a petroleum activity—NOPSEMA; or

b. in relation to a greenhouse gas storage activity—the responsible Commonwealth Minister.

Reportable incident, for an activity, means an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage.

Titleholder means:

a. a greenhouse gas titleholder; or

b. a petroleum titleholder.

Abbreviations

AFFF	Aqueous film forming foam
AFMA	Australian Fisheries Management Authority
AFC	Antifouling coating
AFZ	Australian Fishing Zone
AHD	Australian Heritage Database
AHS	Australian Hydrographic Service
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian & New Zealand Environment and Conservation Council
APASA	Asia-Pacific ASA
API	American Petroleum Institute
APPEA	The Australian Petroleum Production & Exploration Association
ASS	Abandon Ship Shutdown
AUSREP	Australian Ship Reporting System
AUV	Autonomous Underwater Vehicle
Bbl/d	Barrel per day
BIA	Biologically Important Area
BOD	Biochemical Oxygen Demand
BTEX	Benzene Toluene Ethyl-benzene Xylene
CAMBA	China Australia Migratory Bird Agreement (1986)
CBTA	Competency based training assessment
CEO	Chief Executive Officer
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CFA	Commonwealth Fisheries Association
CH_4	Methane
CHARM	Chemical Hazard Assessment And Risk Management
CM	Control Measure
CMMS	Computerised Maintenance Management System
CO_2	Carbon Dioxide
CON	Coniston
CP	Cathodic Protection
CRG	Consultation Reference Group
CVI	Close Visual Inspection
DAHs	Dissolved Aromatic Hydrocarbons
DAWR	Department of Agriculture and Water
DoAWE	Department of Agriculture, Water and Environment

DBCA	Department of Biodiversity, Conservation and Attractions
DC	Drilling Centre
DCS	Distributed Control System
DEC	WA Department of Environment and Conservation (now DPaW and DER)
DEH	Department of Environment and Heritage (now DEWHA)
DER	Western Australia Department of Environment Regulation
DEW	Department of Environment and Water Resources (now DEWHA)
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (previously DEW, DEH)
DGPS	Differential Global Positioning System
DIA	Department of Indigenous Affairs
DoEE	Department of the Environment and Energy
DoAWE	Department of Agriculture, Water and Environment
DoF	Western Australian Department of Fisheries
DOT	Western Australian Department of Transport
DMP	Western Australia Department of Mines and Petroleum
DP	Dynamic Positioning
DPaW	Western Australia Department of Parks and Wildlife
DPIRD	Department of Primary Industry and Regional Development
DoE	Department of the Environment (previously DSEWPaC)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DTM	Disconnectable Turret Mooring
EE	Existing Environment
EHS	Environment, Health and Safety
EMBA	Environment that may be affected
ENVID	Environmental Hazard Identification
EOFL	End of Field Life
EP	Environmental Plan
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standards
ESD	Emergency Shutdown
ESDVs	Emergency Shutdown Valves
FIT	Formation integrity test
FPSO	Floating, Production, Storage and Offloading
GHG	Greenhouse gas
GLJ	Gas Lift Jumper
GPM	Gas Production Manifold

GVI	General Visual Inspection
HEV	High Environmental Value
HFO	Heavy Fuel Oil
HP	High Pressure
HPU	Hydraulic Power Units
HPWHH	High Pressure Well Head Housing
HQ	Hazard Quotient
HSE	Health, Safety and Environment
HSEA	Health, Safety and Environment Advisor
IACS	International Association of Classification Societies
IAPP	International Air Pollution Prevention
IBCs	Intermediate Bulk Containers
ICSS	Integrated Control and Safety System
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMDG Code	International Maritime Dangerous Goods Code
IMMR	Inspection, maintenance, monitoring and repair
IMM	Inspection, maintenance and monitoring
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IMSMP	Invasive Marine Species Management Plan
IMT	Incident management team
INPEX	INPEX Alpha Ltd
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISPP	International Sewage Pollution Prevention
JAMBA	Japan Australia Migratory Bird Agreement (1974)
KEF	Key Environmental Feature
KPI	Key Performance Indicator
LOT	Leak off testing
LOWC	Loss of well control
LP	Low Pressure
LPSG	Low pressure steam generator
LPWHH	Low-Pressure Well Head Housing
MARPOL	International Convention for the Protection of Pollution from Ships (1973) and Protocol (1978)
MBES	Multi-beam echo sounder
MCS	Maximum Credible Spill
MDO	Marine Diesel Oil
MEG	Mono Ethylene Glycol
MCS	Master Control Station
MFO	Marine fauna observer
MNES	Matters of National Environmental Significance

MOC	Management of Change
MODU	Mobile Offshore Drilling Unit
MOU	Memorandum of understanding
MPNMP	Marine Parks Network Management Plan
MPRA	Marine Parks and Reserves Authority
N_2O	Nitrous Oxide
NATA	National Association of Testing Authorities
NatPlan	National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances
NEBA	Net Environmental Benefit Assessment
NMFS	U.S National Marine Fisheries service
NOV	Novara
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NORMs	Naturally Occurring Radioactive Materials
NOx	Nitrogen Oxides
NPI	National Pollutants Inventory
NV Operations	Ningaloo Vision Operations
NWC	North West Cape
NWS	North West Shelf
NWSTF	North West Slope Trawl Fishery
OCIMF	Oil Companies International Marine Forum
OCNS	Offshore Chemical Notification Scheme (UK)
ODS	Ozone depletion substances
OIM	Offshore Installation Manager
OIW	Oil In Water
OMS	Operations Management System
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPGGS(E)R	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OPMF	Onslow Prawn Managed Fishery
OSMP	Operational and Scientific Monitoring Plan
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
OSRT	Oil Spill Response Team
OVID	Offshore Vessel Inspection Database
P and A	Plugged and Abandoned
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring

PC	Protective Concentration
PGS	Production Guide Base
PW	Produced Water
PLET	Pipeline End Termination
PLONOR	Pose Little or No Risk to the Environment
PMS	Planned Maintenance System
PMST	Protected Matters Search Tool
POB	Persons on Board
PRS	Production Reporting System
PSZ	Petroleum Safety Zone
PTS	Permanent threshold shift
RACON	Radar Beacon
RCC	Rescue Coordination Centre
RO	Reverse Osmosis
ROV	Remotely Operated (underwater) Vehicle
SCG	Stakeholder Consultation Group
SCSSV	Surface Controlled Subsurface Safety Valve
SDS	Safety Data Sheet
SIRE	Ship Inspection Report Programme
SMPEP	Shipboard Marine Pollution Emergency Plan
SO_x	Sulphur oxide
SOLAS	Safety of Life At Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPCS	Subsea Pump Control System
SQ	Sediment Quality
SSS	Side Scan Sonar
STCW	Standards of Training, Certification and Watch-keeping for Seafarers
STP	Sewage Treatment Plant
ST	Sidetrack
TBT	Tributyltin
TEG	Tri-ethylene Glycol
TSS	Total Suspended Solids
TTS	Temporary threshold shift
TV	Trigger Value
TVDSS	True Vertical Depth sub-sea
TWAF	Total water-accommodated fraction
UAV	Unmanned Aerial Vehicle
USD	Unit Shut-down
UPS	Uninterruptable power supply
UNCLOS	United Nations Convention on the Law of the Sea (1982)
UWILD	Underwater Inspection in Lieu of Drydocking

VGA/B	Van Gogh A or B
VLF	very low frequency
VOCs	Volatile Organic Compounds
WA	Western Australia
WA OWRP	WA Oiled Wildlife Reponses Plan
WAF	Water-accommodated fraction
WAFIC	WA Fishing Industry Council
WDTF	Western Deepwater Trawl
WHA	World Heritage Area
WOMP	Well Operations Management Plan
WQ	Water Quality
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna and Billfish Fishery
ZOEF	Zone of Established Flow
ZOSF	Zone of Surface Flow

Units of Measurement

bbl/d	Barrels per day
bbl	Barrels
°C	Degrees centigrade
cm	Centimetre (10 mm)
cm^2	Square centimetre
cm^3	Cubic centimetre
dB(A)	A-weighted sound pressure level in decibels
dB	Decibels
dB re 1μPa	Decibels re micro Pascals
Hr	Hour
kL	Kilolitre (1,000 litres)
km	Kilometre (1,000 m)
kHz	Kilohertz
kPa	Kilo Pascal
ksm^3	Thousand standard cubic meters
L	Litre (1000 ml)
m	Metre (100 cm)
m^2	Square metre
m^3	Cubic metre
mcf	Million cubic feet
mg/L	Milligrams per litre
ml	Millilitre
mm	Millimetre
MMboe	Million barrels of oil equivalent
MMSCFD	Millions of Standard Cubic Feet per Day
nm	Nautical mile (1.856 km)
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per thousand
psig	Pounds per Square Inch Gauge
t	Tonne
μg	Microgram

1 Introduction

1.1 EP Summary

OPGGS(E)R 2009 Requirements
Regulation 11(3)
Within 10 days after receiving notice that the Regulator has accepted an environment plan (whether in full, in part or subject to limitations or conditions), the titleholder must submit a summary of the accepted plan to the Regulator for public disclosure.
Regulation 11(4)
The summary: (a) must include the following material from the environment plan: (i) the location of the activity; (ii) a description of the receiving environment; (iii) a description of the activity; (iv) details of environmental impacts and risks; (v) a summary of the control measures for the activity; (vi) a summary of the arrangements for ongoing monitoring of the titleholder's environmental performance; (vii) a summary of the response arrangements in the oil pollution emergency plan; (viii) details of consultation already undertaken, and pans for ongoing consultation; (ix) details of the titleholder's nominated liaison person for the activity; and (b) must be to the satisfaction of the Regulator.

The Environment Plan summary, has been prepared from material provided in this EP. The summary consists of the following as required by Regulation 11(4).

Environment Plan (EP) summary material requirement	Relevant section of EP containing EP Summary material
The location of the activity	**Section 2**
A description of the receiving environment	**Section 3** and **Appendix D**
A description of the activity	**Section 2**
Details of the environmental impacts and risks	**Section 4.5, 6** and **7**
The control measures for the activity	**Section 6, 7** and **8.4.1**
The arrangements for ongoing monitoring of the titleholders environmental performance	**Section 7.11**
Response arrangements in the oil pollution emergency plan	**Section 6.8** and **OPEP**
Consultation already undertaken and plans for ongoing consultation	**Section 4**
Details of the titleholders nominated liaison person for the activity	**Section 1.6.2**

1.2 Background

On 27 November 2018, Santos completed its acquisition of Quadrant Energy. This has the effect that Santos Limited is now the ultimate holding company of Quadrant Energy Holdings Pty Ltd and its subsidiaries. It has also resulted in most of the Quadrant group of entities changing their name. Quadrant Energy Limited has changed its name to Santos Energy Limited. Its ABN (ABN 58 009 140 854) has remained the same. Santos PVG Pty Ltd (thereafter referred to Santos or the Company) will be responsible for all commitments and obligations in this EP.

1.3 Activity Overview

Santos, on behalf of the Coniston-Van Gogh Production Joint Venture titleholders (Santos WA PVG Pty Ltd [52.501% ownership] and INPEX Alpha Ltd [47.499% ownership]) operates the Van Gogh, Coniston and Novara fields located in WA-35-L which recovers oil in production licence area WA-35-L using the Ningaloo Vision floating production, storage and offloading (FPSO) vessel. Historically, oil has been recovered from the Van Gogh field using the Ningaloo Vision FPSO since 2010. Oil from the Van Gogh field will continue to be recovered and comingled with oil from the Coniston and Novara fields. Production rates are currently at approximately 10,000 bbl/d (March 2020) and are expected to decline over the remainder of the field life. Short term increases in production may occur due to infill drilling campaigns. However, the operation of new wells and subsea infrastructure will be undertaken in accordance with this EP. This EP does not include any decommissioning activities. However, an explanation of Santos Asset Management (including that of property removal) is explained in **Section 8.8** Based on current (July 2020) estimates, end of field life could occur between 2025 and 2028. Therefore, cessation of operations is possible during the five year life of this EP.

The development of the three oil fields (Van Gogh, Coniston and Novara) involves recovering hydrocarbons through installed production wells and subsea equipment and directing the production liquids to the FPSO for processing and storage. The FPSO and subsea infrastructure design allows for produced water and excess produced gas (excludes gas required for fuel and gas lift) to be reinjected to the reservoir or discharged overboard. Offtake tankers load the recovered oil from the FPSO on a regular basis. Support vessels provide support for activities such as the loading of supplies, offloading of wastes, assistance for offtake tanker berthing and loading, and oil spill response. Project vessels carry out inspection, maintenance, monitoring and repair (IMMR) activities. Helicopters are used for transport of personnel to and from the facility. Collectively, these activities are referred to as the Ningaloo Vision Operations in this Environment Plan (EP).

Project and support vessels, have been collectively referred to as 'vessels' throughout this EP, whilst the Ningaloo Vision FPSO has been referred to as 'NV FPSO' or 'the FPSO'.

The Ningaloo Vision FPSO may leave the operational area for cyclone avoidance or for maintenance activities (e.g. shipyard campaigns). This EP covers petroleum activities within the operational area despite the FPSO not being on location within it.

1.3.1 Location of the Activity

The FPSO and subsea infrastructure are located within Production Licence WA-35-L in Commonwealth waters, approximately 45 km north-northwest off the Cape Range Peninsula in Western Australia. The FPSO is located 53 km north-northwest of the Exmouth township and 27 km from the northern boundary of Ningaloo Australian Marine Park (**Figure 2-1**). The Ningaloo Vision operations occur in water depths ranging from 340 m in the east of the production licence to 400 m in the west, with the FPSO moored in a water depth of 341 m. The nominal proximity of the Ningaloo Vision operational area to other key coastal or mainland features is:

+ State/Commonwealth waters boundary – 32.3 km southeast;
+ Ningaloo Marine Park boundary – 33.6 km southeast;
+ Muiron Islands Marine Management Area – 32.3 km southeast;

- North West Cape – 41.6 km south; and
- Barrow Island – 137 km northeast.

1.4 Purpose of this Environment Plan

OPGGS(E)R 2009 Requirements
Regulation 19(1)
A titleholder must submit to the Regulator a proposed revision of the environment plan for an activity at least 14 days before the end of each period of 5 years, commencing on the latest of the following: (a) the day on which the environment plan is first accepted under regulation 10 by the Regulator; (b) the day on which a revised environment plan submitted under this regulation is accepted under regulation 10 by the Regulator; (c) for a revision of an environment plan submitted under regulation 17 or 18, the day (if any) notified by the Regulator under subregulation (2).
Regulation 19(2)
For paragraph (1)(c), the Regulator may notify the title holder that the effect of a revision of an environment plan submitted under regulation 17 or 18 is that the period of 5 years mentioned in subregulation (1) starts on the date specified in the notification.

This EP has been prepared in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E)R) for acceptance by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

This EP details the environmental impacts and risks associated with the activity and demonstrates how these will be reduced to as low as reasonably practicable (ALARP) and to an acceptable level. The EP provides an implementation strategy (**Section 8**) that is used to measure and report on environmental performance during planned activities and unplanned events to ensure impacts and risks are continuously reduced to ALARP and are at an acceptable level. The environmental management of the activity described in the EP complies with the Santos Environment Health and Safety Policy (**Appendix A**) and with all relevant legislation (**Appendix B**). This EP documents and considers all relevant stakeholder consultation performed during the planning of the activity.

A stand-alone environmental approval to undertake decommissioning of the Ningaloo Vision Operations will be sought from NOPSEMA (or the equivalent agency at the time) and other government authorities under the relevant legislation closer to the time of the activity.

1.5 Environment Plan Validity

In accordance with Regulation 19, this EP remains valid from NOPSEMA acceptance for a period of five years, or until NOPSEMA has accepted an end-of-activity notification under Regulation 25A or Santos revise and resubmit this EP.

1.6 Titleholder

1.6.1 Details of the Titleholder

OPGGS(E)R 2009 Requirements
Regulation 15. Details of titleholder and liaison person
15(1) The environment plan must include the following details for the titleholder: (a) name; (b) business address;

(c) telephone number (if any); (d) fax number (if any); (e) email address (if any); (f) if the titleholder is a body corporate that has an ACN (within the meaning of the Corporations Act 2001)—ACN. 15(2) The environment plan must also include the following details for the titleholder's nominated liaison person: (a) name; (b) business address; (c) telephone number (if any); (d) fax number (if any); (e) email address (if any).

Santos WA PVG Pty Ltd is the nominated titleholder for the petroleum activity covered under this EP within WA-35-L.

In accordance with Regulation 15(1) of the OPGGS(E)R, the titleholder details are as follows:

Name: Santos WA PVG Pty Ltd

Business address: 100 St Georges Terrace, Perth, WA 6000

Telephone number: (08) 6218 7100

Email address: offshore.environment.admin@santos.com

ACN: 129 604 860

1.6.2 Details for Nominated Liaison Person

Details for the Santos Nominated Liaison Person for the activity are as follows:

Name: A Smith

Position: Manager – NV Production Manager

Address: 100 St Georges Terrace, Perth, 6000

Telephone number: (08) 6218 7100

Email address: offshore.environment.admin@santos.com

1.6.3 Notification Procedure in the Event of Changed Details

If there is a change in the titleholder, the titleholder's nominated liaison person, or a change in the contact details for the titleholder or liaison person, Santos will notify NOPSEMA in writing and provide the updated details.

Additional information regarding the Santos operations can be obtained from the Santos website at: www.santos.com.

1.7 Environmental Management Framework

OPGGS(E)R 2009 Requirements
Regulation 16(a). Other information in the environment plan
The environment plan must contain the following: (a) A statement of the titleholder's corporate environmental policy;

1.7.1 Environment Health and Safety Policy

The activities will be conducted in accordance with the Santos Environment Health and Safety Policy (**Appendix A**) and relevant legislative requirements presented within **Appendix B** inclusive of the relevant EP sections where the legislation may prescribe or control how an activity is undertaken.

Sections 6 and **7** reflect the Santos Environment Health and Safety Policy, detailing and evaluating impacts and risks from planned and unplanned events, providing control measures with set performance outcomes, standards, and measurement criteria to ensuring environmental performance is achieved.

1.8 Legislative Framework

1.8.1 International Legislation

Australia is signatory to numerous international conventions and agreements that obligate the Commonwealth government to prevent pollution and protect specified habitats, flora and fauna. Those which are relevant to the operation of the FPSO and associated infrastructure are detailed in **Appendix B.**

1.8.2 Commonwealth and State Legislation

All activities conducted during the operation of the FPSO and associated infrastructure will comply with legislative requirements established under relevant State and Commonwealth legislation. These are further detailed in **Appendix B.**

1.8.2.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) is the principal legislation managing petroleum activities in Australian Commonwealth waters. The objective of the OPGGS Act is to ensure that offshore petroleum operations are performed in a way that is consistent with the principles of ecologically sustainable development.

The OPGGS Act and supporting regulations address all licensing, health, safety environmental and royalty issues for offshore petroleum and gas exploration and production operations in Commonwealth waters.

Specifically, the OPGGS(E)R 2009 prescribe the requirements for management of environmental impacts associated with petroleum activities and require proponents to submit an EP to the Regulatory Authority for approval prior to the commencement of activities. As part of these documents, the proponent is required to assess the risks associated with the activities and demonstrate that the proposed mitigation measures reduce these risks to ALARP and acceptable levels.

Appendix B includes the pertinent sections of the OPGGS(E)R 2009 and details the sections of the EP which ensure compliance with the requirements.

1.8.2.2 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Van Gogh Development was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA; now Department of Agriculture, Water and Environment [DoAWE]) on 3 January 2007 (Ref. EPBC 2007/3213). The DEWHA determined that the development was a “controlled action” requiring approval under Part 3, Division 1 of the EPBC Act pertaining to:

+ Listed threatened species and communities;
+ Listed migratory species; and
+ Commonwealth marine areas.

An assessment of the applicability of the EPBC conditions of approval (which have been formally varied over time) for the operational phases of the Van Gogh and the Coniston and Novara developments is provided in **Appendix B**, where a description is provided on the history of the Van Gogh and Coniston Novara EPBC Approvals and how this EP gives effect to the conditions of Approval.

1.8.3 International Legislation

Australia is signatory to numerous international conventions and agreements that obligate the Commonwealth government to prevent pollution and protect specified habitats, flora and fauna. Those which have been considered during development of this EP are detailed in **Appendix B**.

2 Activity Description

OPGGS(E)R 2009 Requirements
Regulation 13(1)
Description of the activity 13(1) The environment plan must contain a comprehensive description of the activity including the following: (a) the location or locations of the activity; (b) general details of the construction and layout of any facility; (c) an outline of the operational details of the activity (for example, seismic surveys, exploration drilling or production) and proposed timetables; and (d) any additional information relevant to consideration of environmental impacts and risks of the activity. Note: An environment plan will not be capable of being accepted by the Regulator if an activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, will be undertaken in any part of a declared World Heritage property – see Regulation 10A.

Section 2 provides a description of the Ningaloo Vision FPSO (the FPSO) and the subsea infrastructure and activities within the operational area (**Section 2.2**) associated with recovering oil from the Van Gogh, Coniston and Novara fields.

2.1 Description of the Field

The Van Gogh, Coniston and Novara fields are oil reservoirs. Production commenced from the Van Gogh field in 2010. The Coniston and Novara fields were brought into production in 2015 and 2016, respectively and are located approximately 8 km and 10 km north of the FPSO. Further infill drilling of the Van Gogh Field commenced in September 2018 with production from two wells commencing in January 2019.

Oil production rates are approximately 10,000 bbls/day (as at March 2020) and will decline naturally with time, which will correspond with a continued increase in produced formation water. Occasional increases in oil rate may occur through production well optimisation and potential further field development such as infill wells.

The current (March 2020) anticipated life of the FPSO extends until approximately 2030 with a shipyard campaign scheduled in 2020.

2.2 Operational Area

This EP covers Ningaloo Vision Operations (NV Operations) within an operational area (refer **Figure 2-1**) defined as:

+ A 500 m radius petroleum safety zone (PSZ) that extends around the Disconnectable Turret Mooring (DTM) buoy;
+ A 500 m radius around the DTM anchor spread; and
+ 500 m around and either side of all other subsea field infrastructure.

The operational area is solely located in production licence WA-35-L.

Planned events and resultant impacts from the NV Operations are detailed in **Section 6**. The greatest spatial extent of any impact from a planned operational event is that from produced water (PW) discharges (**Section 6.7)**. Impacts from PW discharges may occur within surface waters within a PW impact area (referred to as the PW mixing zone) defined as a 459 m radius around the FPSO discharge point (**Section 6.7)**.

Potential unplanned (accidental) events and spill response activities may lead to environmental impacts within a spatial extent greater than that for the planned events (refer **Section 7**).

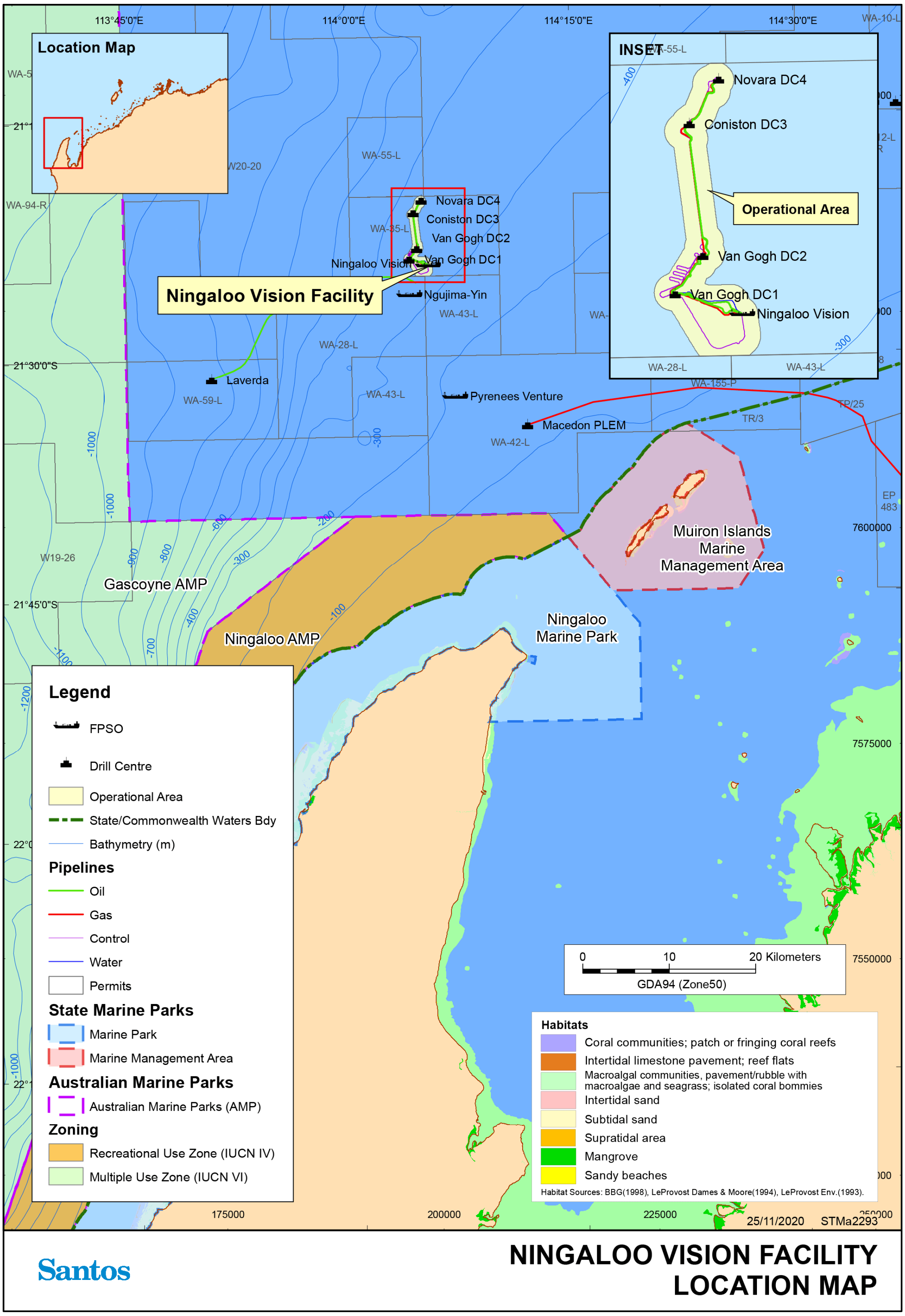

Figure 2-1: Location of Ningaloo Vision and Associated Infrastructure

2.3 Subsea Infrastructure

The subsea infrastructure (as illustrated in **Figure 2-2**) for NV Operations includes:

- Oil and gas subsea production wells;
- Gas and water reinjection wells;
- Dis-connectable Turret Mooring (DTM) mooring points;
- Umbilicals (hydrocarbon, hydraulic, production chemicals, electrical) connecting wells to manifolds and the FPSO to the Drill Centres;
- Four subsea Drill Centres (DC) also known as manifolds;
- Gas Production Manifold;
- Water injection Pipeline End Termination (PLET);
- Flexible jumpers (e.g. gas lift) and rigid spools connecting wells to manifolds;
- Ancillary equipment connecting the power/communications/fluids to the subsea equipment; and
- Flexible flowlines and risers connecting manifolds to the FPSO and between the subsea manifolds.

Locations of the major NV Operations infrastructure are provided in **Table 2-1.** Wells drilled from the manifolds have been further defined in **Table 2-2**.

Collectively the subsea infrastructure (excluding the subsea wells, but including the subsea trees) is referred to as the ‘subsea system’.

Table 2-1: Location of Infrastructure Associated with the NV Operations

Infrastructure Locations	Status*	Coordinates (Datum/Projection: GDA 94 Zone 50)			
		Latitude (South)	Longitude (East)	Easting (m)	Northing (m)
FPSO mooring position	Active	21°24'12.39"	114°05'17.22"	198096	7630400
DTM Mooring Point 1 (centred)	Active	21°23'32.43"	114°05'08.43"	197820	12368375
DTM Mooring Point 2 (centred)	Active	21°22'05.43"	114°05'28.89"	198360	12365687
DTM Mooring Point 3 (centred)	Active	21°24'39.45"	114°04'45.24"	197190	12370450
Pipeline End Termination (PLET) for PW reinjection wells 1 & 2	Active	21°23'50.17"	114°04'06.23"	196037	7631046
Gas Production Manifold (GPM)	Active	21°23'51.68"	114°04'03.86"	195970	7630998
Van Gogh Sub-sea Production Manifold A (DC 1)	Active	21° 23' 51.34"	114°04'04.75"	195995	7631009
Van Gogh Sub-sea Production Manifold B (DC 2)	Active	21°23'12.71"	114°04'35.91"	196871	763221
Coniston Subsea Production Manifold (DC 3)	Active	21˚20'57.29"	114˚04'23.61"	196439	7636375
Novara Subsea Production Manifold (DC 4)	Active	21˚20'12.33"	114˚04'55.95"	197346	7637776

*Current status at EP submission

2.4 Subsea Wells

Twenty-two subsea wells have been drilled in production licence WA-35-L from four manifolds (**Table 2-2**), these wells are currently active.

Well status may change within the five-year tenure of this EP. Any change in status (e.g. active to inactive, well intervention, suspension and abandonment) is managed in accordance with the in-force NOSPEMA Accepted Well Operations Management Plan (WOMP) and subject to the Management of Change process (**Section 8.12.2**).

There are three plugged and abandoned wells listed on WA-35-L, summarised below:

- Crusader-1: Vertical exploration well drilled in Feb/March 2011. The well was P&A'd as reported in March 2011 with surface casing cut below the mud-line and the wellhead system removed from the sea-bed (LPWHH, HPWHH, PGB and casing cut-off).
- Coniston-2 (Coniston-2, 2CH1, 2H and 2HST1): Appraisal well drilled in August/September 2009. The well was P&A'd as reported by Sept 2009 with surface casing cut ~2m below the mud-line and the wellhead system removed from the sea-bed.
- Novara-2 (Novara-2PH, 3, 3ST1 and 3H): Appraisal well drilled in July/August 2009. The well was P&A'd as reported by August 2009 with surface casing cut ~4m below the mud-line and the wellhead system removed from the sea-bed.

Table 2-3 presents a summary of the wells and coordinates, including their sidetracks. These wells are considered outside of the scope of the EP and have been provided for reference only and are not discussed further.

Table 2-2: Active wells within WA-35-L

Manifold	Well name	Well type	Water depth (m)	Coordinates (Datum/Projection: GDA 94 Zone 50)				Well Status*
				Latitude (South)	Longitude (East)	Easting (m)	Northing (m)	
DC1	Theo-3H	Oil Production Well	367	21° 23’ 52.092”	114° 04’ 05.320”	196,012.38	7,630,986.03	Active
	VGA-2H	Oil Production Well	367	21° 23’ 52.070”	114° 04’ 04.581”	195,991.05	7,630,986.32	Active
	VGA-3H	Oil Production Well	367	21° 23’ 52.080”	114° 04’ 04.946”	196,001.60	7,630,986.20	Active
	VGA-4H GI	Gas Injection/Production	367	21° 23’ 52.186”	114° 04’ 04.147”	195,978.63	7,630,982.51	Active
	VGA-5H	Oil Production Well	367.5	21° 23’ 50.480”	114° 04’ 05.398”	195,978.63	7,631,035.68	Active
	VGA-6H	Oil Production Well	367	21° 23’ 50.460”	114° 04’ 04.648”	195,992.06	7,631,035.91	Active
	VGA-7H	Oil Production Well	367	21° 23’ 50.468”	114° 04’ 05.040”	196,003.38	7,631,035.86	Active
	VGA-12 WI1	Water Injection Well	367	21° 23’ 50.754”	114° 04’ 05.717”	196,023.05	7,631,027.42	Active
	VGA-13 WI2	Water Injection Well	367	21° 23’ 50.874”	114° 04’ 06.122”	196,034.79	7,631,023.96	Active
DC2	VGB-8H	Oil Production Well	362	21° 23’ 13.541”	114° 04’ 35.559”	196,861.76	7,632,188.66	Active
	VGB-9H	Oil Production Well	362	21° 23’ 13.509”	114° 04’ 35.884”	196,871.12	7,632,189.79	Active
	VGB-10H	Oil Production Well	362	21° 23’ 13.539”	114° 04’ 36.236”	196,881.28	7,632,189.07	Active
	VGB-11H	Oil Production Well	362	21° 23’ 11.929”	114° 04’ 36.289”	196,881.87	7,632,238.63	Active
	VGB-14H	Oil Production Well	362	21° 23’ 11.87”	114° 04’ 35.53”E	196,860m	7,632,240m	Active
	VGB-15H	Oil Production Well	362	21° 23’ 11.88”	114° 04’ 35.88”	196,870m	7,632,240m	Active
DC3	CON-10H	Oil Production Well	377.75	21° 20’ 58.214”	114° 04’ 23.820”	196,445.84	7,636,346.83	Active
	CON-11H	Oil Production Well	379.95	21° 20’ 56.952”	114° 04’ 22.637”	196,411.01	7,636,385.03	Active
	CON-12H	Oil Production Well	378.15	21° 20’ 57.936”	114° 04’ 24.166”	196,455.65	7,636,355.58	Active

	CON-13H	Oil Production Well	379.15	21° 20’ 56.651”	114° 04’ 23.035”	196,442.31	7,636,394.51	Active
	CON-14H	Oil Production Well	377.75	21° 20’ 56.338”	114° 04’ 23.426”	196,433.41	7,636,404.35	Active
	CON-15H	Oil Production Well	378.15	21° 20’ 57.622”	114° 04’ 24.600”	196,468.00	7,636,365.45	Active
DC4	NOV-4H	Oil Production Well	373.24	21° 20’ 11.78”	114° 04’ 56.60”	197,364.38	7,637,793.20	Active

*current status at EP submission

Table 2-3: Abandoned wells within WA-35-L

Well name	Well type	Coordinates (Datum/Projection: GDA 94 Zone 50)		Well Status*
		Latitude(South)	Longitude (East	
Crusader 1	Exploration	21° 39’ 70.764”	114° 02’ 25.908”	Abandoned
Coniston 2	Appraisal	21° 34’ 38.369”	114° 08’ 35.89”	Abandoned
Coniston 2 CH1	Appraisal	21° 39’ 70.764”	114° 02’ 25.908”	Abandoned
Coniston 2H	Appraisal	21° 34’ 38.369”	114° 08’ 35.89”	Abandoned
Coniston 2H ST1	Appraisal	21° 39’ 70.764”	114° 02’ 25.908”	Abandoned
Novara 3H	Development	21° 34’ 65.53”	114° 08’ 35.89”	Abandoned
Novara 3 ST1	Development	21° 34’ 65.53”	114° 08’ 35.89”	Abandoned
Novara 3	Development	21° 34’ 65.53”	114° 08’ 35.89”	Abandoned
Novara 2 PH	Development	21° 34’ 65.53”	114° 08’ 35.89”	Abandoned

*Status as per NOPIMs database

2.5 Disconnectable Turret Mooring System

The FPSO has a disconnectable type internal turret, referred to as the Disconnectable Turret Mooring (DTM) system, installed inside a fabricated moonpool structure (caisson) near the bow of the vessel within the centre void tank no. 1. The DTM system allows the FPSO to weathervane around the mooring in response to the prevailing weather conditions. The system provides support for the riser and umbilical system and mooring lines as well as fluid / electrical / swivels and pipework.

The DTM system main components include:

+ The DTM buoy; and
+ The Moonpool and Turret.

2.5.1 DTM Buoy

The DTM buoy's main function is to collect the risers, connect them to the FPSO and provide the mooring system for the FPSO and tandem-moored offload tankers. The DTM buoy is anchored to the seabed at nine mooring points (**Figure 2-2**). The DTM buoy is connected to the turret (**Section 2.5.2**) and locked in place by pawls.

The DTM buoy is provided with nine riser connections, of which four are spares for possible future tie-ins.

The DTM buoy is submerged approximately 30 m below sea level upon FPSO disconnect and the 500 m PSZ around it remains.

2.5.1.1 FPSO Disconnection and Re-connection

The FPSO may disconnect from the DTM buoy for cyclone avoidance or to leave the field for maintenance activities (e.g. shipyard campaigns).

The DTM buoy is designed such that the FPSO does not necessarily need to be disconnected during a 100 year return non-cyclonic event. However, in order to allow for a decision to be made to avoid extreme weather conditions such as cyclones, the FPSO is equipped for disconnection and reconnection with the DTM buoy. The DTM buoy is located and connected to the FPSO with the assistance of a differential global positioning system (DGPS). The DTM buoy is winched into the moonpool within the FPSO using a floating pick up line (rope type) arrangement that is left attached to the DTM (made up of a DTM lifting line assembly, and temporary pick up lines), and then locked into place. The DTM buoy is designed to submerge within the water column (approximately 30 m below sea level) after disconnection whilst remaining capable of supporting the submerged risers and mooring lines.

Prior to a disconnection of the DTM buoy, the flowlines are isolated by closing a series of valves, the surface pipework is depressurised, and then flushed or purged with water or nitrogen before physical disconnection.

2.5.2 Moonpool and Turret

The moonpool is a void created within the bow area of the FPSO through conversion of the forwardmost oil storage tank into a caisson. The moonpool is not sealed or watertight and water level in it varies according to the vessels forward draft. The void has gratings on the pull in deck which aid in ventilation of the space in conjunction with fixed extraction fans. The moonpool houses the DTM buoy when the FPSO is moored and is equipped with internal inspection, access and escape ways.

The turret, being the topsides structure of the DTM buoy, sits directly above the moonpool. The turret serves as the junction point between the DTM buoy and the FPSO topsides production and treatment systems. Risers in the buoy are connected to a series of corresponding pipework on the deck of the FPSO, leading to the processing, treatment and reinjection facilities (**Section 2.6.3**).

A swivel arrangement in the turret structure allows the FPSO to weathervane. The rotating action is controlled by a series of bearings within the turret infrastructure and the DTM buoy. Fluid paths from the stationary riser and buoy section pass through the swivel located near the top of the turret and onto the FPSO.

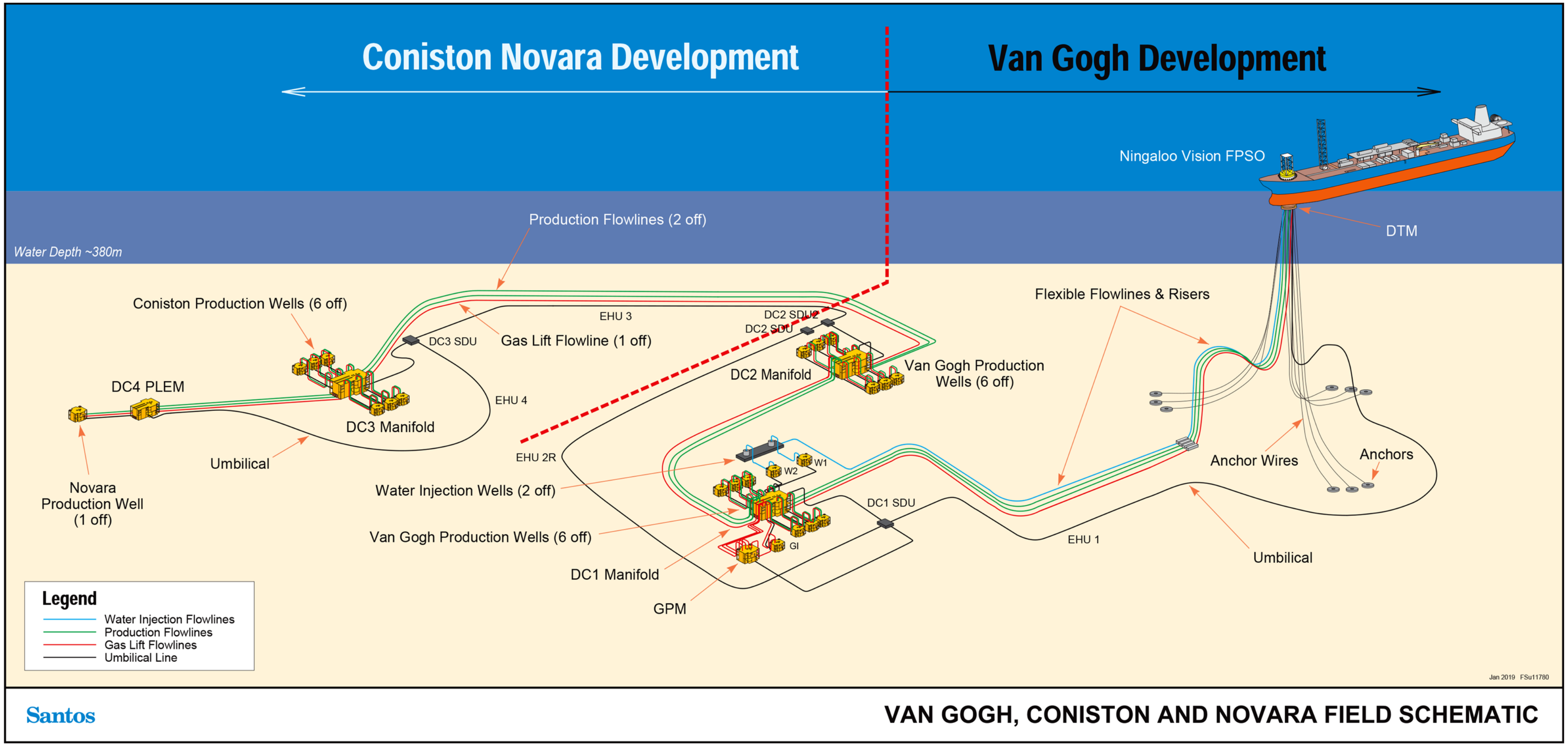

Figure 2-2: Schematic of the Ningaloo Vision Operations Subsea Infrastructure

2.6 Ningaloo Vision: Floating Production, Storage and Offloading Vessel

2.6.1 Construction and Design

The NV FPSO was formerly an 'Aframax' size oil transport tanker, which was converted to an FPSO in 2007 (**Figure 2-3**). The FPSO has purpose-built topside facilities which separate, stabilise and dehydrate oil and gas drawn from the subsea fields. The FPSO has a maximum persons on board (POB) capacity of 65.

Figure 2-3: The Ningaloo Vision FPSO

The overall dimensions of the FPSO are approximately:

+ Length: 244 m;
+ Depth: 24 m;
+ Breadth: 42 m; and
+ Draft (fully loaded): 15 m.

The FPSO is configured to operate under the Flag State requirements, International Association of Classification Societies (IACS) class requirements (third party validation and classification by Lloyds Register of Shipping) and International Maritime Organisation (IMO) (International Convention for the Protection of Pollution from Ships (1973) and Protocol (1978) [MARPOL] and Safety of Life at Sea [SOLAS]) requirements.

The FPSO has cargo tanks which are double-sided design and provide two physical barriers between oil and the marine environment.

2.6.2 Topsides

The major physical structures comprising the topsides of the FPSO include:

+ Offloading hose and hawser and associated reels.
+ Helideck.

+ Accommodation and control facilities, including central control room.
+ Steam boilers.
+ Steam turbines.
+ Cranes, including laydown crane and supply offloading area.
+ Cooling systems.
+ Chemical storage area.
+ PW treatment and disposal.
+ Fire water systems.
+ Gas dehydration module.
+ Oil separation module.
+ Gas compression module.
+ Turret infrastructure.
+ Flare tower and knock out module
+ Gas vents.
+ Electrical switch room.
+ Bunkering station.

The lay-out of the topsides is schematically shown in **Figure 2-4**.

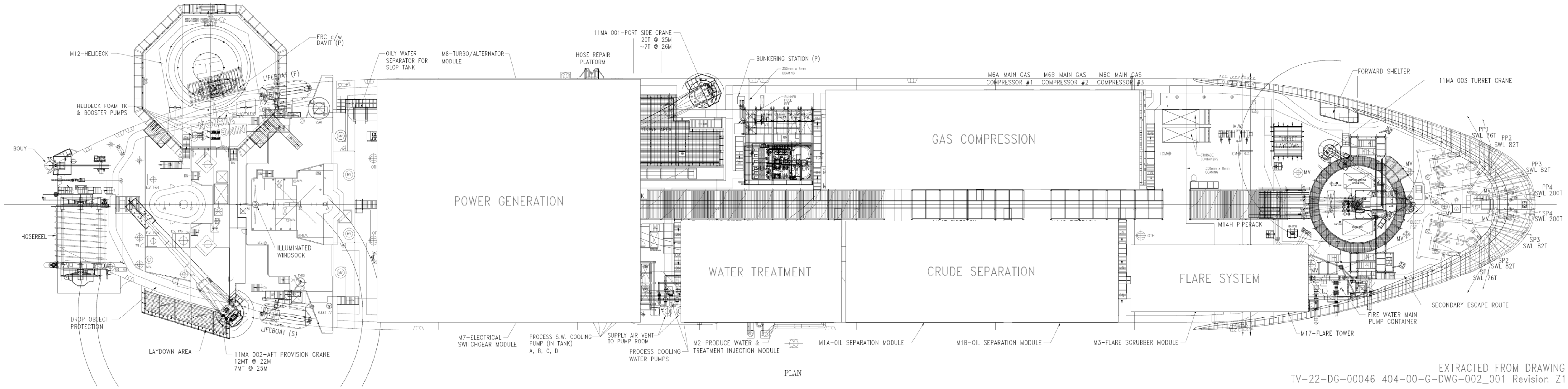

Figure 2-4: FPSO Topside Schematic

2.6.3 Emergency Shutdown

The topsides process system is divided into discrete sections segregated by emergency shutdown valves (ESDVs) which:

+ minimises the inventories released in a loss of containment incident;
+ segregates high and low pressure inventories; and
+ enables blow down of designated sections of the system.

The subsea wells have SCSSVs (excluding water injectors) and actuated valves on the Xmas trees. Each riser has an ESDV upstream of the swivel.

Five levels of emergency shutdown are provided, as defined below:

+ ASS - Abandon Ship Shutdown: This highest shutdown level is only activated when a hazardous event has escalated to a point where it is considered not safe for personnel to remain on the FPSO. ASS is initiated by manual push buttons only, located in the PCR, helideck and lifeboat stations.
+ ESD1 - Manual Emergency Shutdown: The response to the escalation or occurrence of a hazard whereby the integrity of the vessel is in doubt and preparation for abandonment is commencing. ESD1 is initiated by manual push buttons only, located in the PCR, helideck and lifeboat stations.
+ ESD2 - Manual and Automatic Emergency Shutdown: Initiated either by the Fire and Gas System, in response to confirmed fire and/or detection of flammable vapour in designated areas, or by manual ESD2 push buttons located around all areas of the FPSO. ESD2 initiates a total production shutdown and blowdown.
+ PSD - Total Production Shutdown: Initiated when abnormal process operating conditions occur, such as high-high level in the HP flare knock out drum or LP flare knock out drum. PSD is initiated automatically or by a manual push button located in the PCR.
+ USD – Unit Shutdown: Initiated when abnormal operating conditions occur within a system or piece of equipment. USD is initiated either automatically or by manual push buttons dedicated to the specific system or equipment.

The emergency shutdown (ESD) system is fail-safe and can be initiated automatically by sensors contained within the Integrated Control and Safety System (ICSS), or manually, to initiate actions such that the FPSO systems remain within their defined parameters.

Signals from the ESD system interface with the SPCS, e.g. to initiate closure of wing, master, or surface controlled subsurface safety valve (SCSSV) valves dependent upon ESD level. The subsea pump control system (SPCS) is managed by the subsea Master Control Station (MCS) which carries out all logic associated with the control and shutdown functions of the subsea systems. In addition to this communication interface, a hardwired interface is used between the subsea MCS and the topsides ICSS.

2.6.4 Emergency Relief and Blowdown Systems

Emergency relief systems are provided on the FPSO so that the pressure in the system does not exceed the design pressure and eliminate the possibility of loss of containment due to overpressure.

As the subsea flowlines and manifold piping has been designed to withstand pressures in excess of the well shut-in pressure, no subsea emergency relief or blowdown systems are required as there is no risk of loss of containment due to overpressure within the subsea system.

The topside hydrocarbon processing systems have Pressure Safety Valves (PSVs) sized to meet the design requirements. PSVs are provided for fire/thermal relief or provided for a blocked flow relieving scenario. The PSVs are routed to either the HP or LP flare system.

The blowdown system ensures that the topsides hydrocarbon inventory can be safely relieved to the flare system either automatically in an emergency or manually as part of operational requirements.

The risers can be manually depressurised via the topside manifolds.

2.7 Processing and Treatment Systems

The processing and treatment systems on the FPSO include the following:

+ Oil processing system for the recovered crude oil including crude stabilisation, dehydration, storage with inert gas blanketing;
+ Gas treatment system, including dehydration, compression for gas lift and reinjection;
+ Gas flare system; and
+ PW treatment system for the reduction of entrained hydrocarbon and gas within the separated produced formation water for its disposal.

The nominal design capacities of the FPSO's processing and treatment facilities are as follows:

+	Total liquids processing:	23,850 m^3/day (150,000 bbl/d);
+	Oil processing:	10,000 m^3/day (63,000 bbl/d);
+	Oil storage at 100% capacity:	103,333 m^3 (649,883 bbls);
+	Total slops storage at 100% capacity:	8,256 m^3 (51,930 bbls);
+	Produced water disposal (name plate capacity):	8,530,206 m^3/year (147,000 bbl/d);
+	Nominal gas re-injection/lift rates:	2,265 ksm^3/day (80 MMSCFD); and
+	Gas lift (from gas injector):	850 ksm^3/day (30 MMSCFD) (included in total gas re-injection).

The above numbers represent name plate design figures. Day to day figures may vary depending on reservoir performance, production optimisation and limitations.

2.7.1 Oil Processing System

The oil processing system consists of crude separation, crude dehydration and sand removal systems. The main function of the oil processing system is to stabilise crude oil suitable for storage and export.

The crude oil process circuit consists of three stages of crude stabilisation and dehydration along with inter-stage heating, these being:

+ First-stage separation/slug catching (two first-stage separators, A & B) followed by inter-stage heating to break any emulsions and assist with separating the associated gas;
  - Inter-stage heating is provided to heat the produced fluids to the required temperatures to break emulsions and to stabilise the oil. Waste heat recovered from other areas of the process is used to minimise the requirement for additional dedicated heating and cooling systems.
+ Second-stage separation and water knock out (dehydration); and
+ Third stage stabilisation and oil polishing.

After passing through these three stages, the crude is then pumped to the crude storage tanks in the hull of the FPSO. The recovered gas is collected and directed to the gas treatment system (**Section 2.7.2**) while the water is directed to the PW treatment system (**Section 2.7.5**).

2.7.2 Gas Treatment System

Gas recovered from the first stage of separation is used for fuel gas and compressed and dehydrated for reinjection and lift gas purposes. The gas treatment system consists of:

+ Gas compression units; and
+ Gas dehydration (water removal), utilising tri-ethylene glycol (TEG) and the associated regeneration system to dry the gas and recycle the TEG.

2.7.3 Gas Reinjection and Gas Lift

Under normal production operations, gas produced is either:

+ Used for gas lift; and
+ Reinjected downhole.

The gas reinjection system can also be used for start-ups by back flowing from the reinjection system for gas lift and to the topsides gas treating and fuel gas system. This allows for the start-up of the utility systems requiring fuel gas.

2.7.4 Gas Flare System

A high pressure (HP) and low pressure (LP) flare system is provided on the FPSO for safe disposal of gaseous hydrocarbons. The flare tower is located on the starboard side of the FPSO and to the rear of the turret assembly (Refer **Figure 2-4**).

Process flaring occurs during normal production operations. However, at certain times there will be a requirement for increased flare rates due to activities such as:

+ Manual depressurisation of topsides equipment;
+ Planned start-ups and shutdowns;
+ During process upsets; and
+ During periods of flow instability.

The flare system also safely disposes of produced gas in case of an emergency situation (**Section 2.6.3** and **2.6.4**).

2.7.5 Produced Water Treatment and Discharge System

The Production Water (PW) Treatment and Discharge System is designed to separate oil from water and polish PW that is brought to the surface from the production wells along with reservoir fluid. The system utilises several techniques to stabilise the fluid and separate oil in water prior to any returning oil sent back to the process oil treatment system.

The PW Treatment and Discharge System consists of multiple stages of de-oiling, solids removal and pumping equipment. The system consists of the following equipment:

+ Degasser;
+ Hydrocyclone filters;
+ Hydrocyclones;
+ Floatation vessel;
+ Water injection water coolers; and
+ Water injection water pumps.

PW drawn from the production separation system, is fed to the degasser for dissolved gas removal. Gas is routed back to the flare system (**Section 2.7.4**). The degassed water is pumped through filters for solids removal from which the wet sand is collected and bagged for onshore disposal at a licensed waste disposal facility. The PW then passes through hydrocyclones for oil removal and through the PW floatation vessel for further polishing. Removed oil is processed through the oil processing system (**Section 2.7.1**).

The PW oil content is analysed post treatment as per **Section 2.7.5.2,** below.

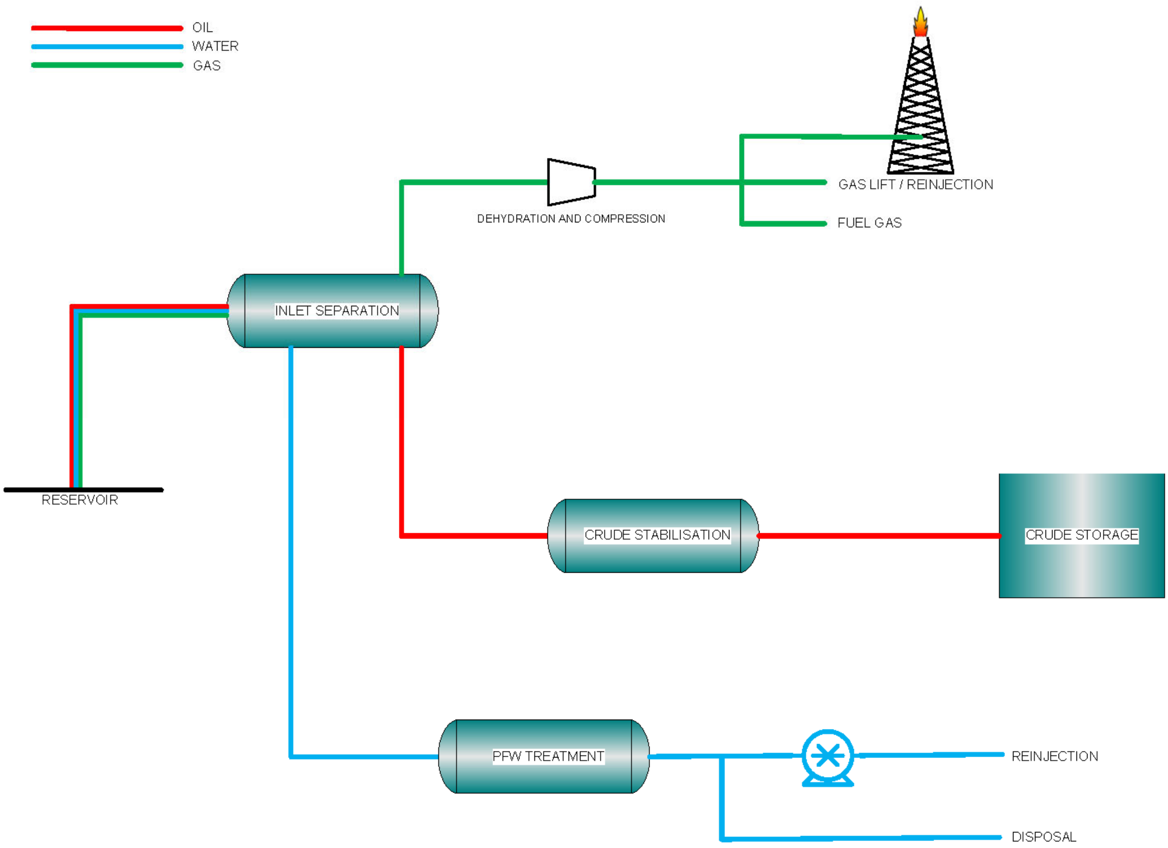

Figure 2-5: PW Treatment System Schematic

2.7.5.1 PW Discharge

The PW Treatment and Discharge System has a designed maximum daily discharge rate of 147,000 bwpd (23,040 m^3). Historically there has been no discharge of PW to the marine environment despite significant system upgrades during the 2014 – 2015 shipyard campaign in anticipation of overboard discharge. The ongoing preference is for downhole re-injection under normal operating conditions.

The PW Treatment and Discharge System is designed so PW can be discharged to an injection well or to the marine environment. Discharge to the marine environment is via a shared outlet (amidships). Dependent on ship's ballast the discharge is between 2-7 m above sea level.

Off-specification PW (not suitable for overboard discharge) may also be routed to the slops tank prior to reprocessing through the PW Treatment and Discharge System. Two slops tanks are available, each has a capacity of 4,128 m^3.

There is no set volume of slops tank capacity that is constantly available for receiving off-specification PW. The slops tank is also used for off-specification water from various sources on the FPSO, with varying available capacity of the slops tanks due to operational requirements.

2.7.5.2 Oil in Water Measurement

Oil in water (OIW) levels in the PW are measured post treatment in the floatation vessel prior to discharge. OIW is typically measured using an inline OIW analyser. The OIW detects and measures soluble hydrocarbons (aromatic hydrocarbons) in water.

PW can typically only be directed overboard if OIW levels are ≤30 mg/L on a rolling 24-hour average. The system will also allow for an atypical discharge of ≤70 mg/L 24 hour rolling average for up to 7 days, limited to two specific events (preceded by a loss in PW injection capacity): to bring wells online and for starting up after being off station (**Table 6-19)** (Refer **Section 6.7.1**).

The OIW analyser will notify the operator if there is failure to return a reading.

If OIW level measurements exceed the limits set in the Environmental Performance Standard, PW can be diverted inboard via diversion valve on the discharge line to the slops tanks for a period as part of an overall series of actions to bring the OIW back into acceptable limits (refer **Section 6.7.3**).

In addition to OIW level monitoring, monitoring also includes routine chemical characterisation and ecotoxicity assessments.

Further details on the discharge of PW to the marine environment from the FPSO, volumes, controls in place to minimise environmental impact and ALARP and acceptability of the discharge are provided in **Section 6.7**.

2.8 Ancillary Systems

Ancillary systems on the FPSO support operations and consist of:

+ Power generation and distribution;
+ Lighting;
+ Process cooling and heating;
+ Nitrogen system;
+ Fresh water production;
+ Hydraulic and lube oil;
+ Drainage system;
+ Chemicals;
+ Waste storage and disposal;
+ Fire and gas detection and fire fighting equipment; and
+ Putrescible waste and sewage treatment.

2.8.1 Communications, Power Generation and Distribution

Produced gas is used as the primary fuel supply on the FPSO. The gas is fed through a fuel gas system before being delivered to the:

+ Boilers;
+ Pressure vessels for blanketing purposes;
+ Flare headers for purging;
+ Flare system for pilot gas; and
+ Glycol regeneration process (**Section 2.7.2**) as stripping gas.

Main electrical power for the FPSO and operational requirements is generated by two steam driven turbine alternators. These electrical power generators normally produce sufficient power for facility operations. However, load shedding (reducing electrical load by preventatively turning off a specific system) is occasionally required due to either reduced power generation capacity or increased power usage requirements. Load shedding priorities are driven by operational and safety requirements, process stability and other dynamic system constraints, and when occasionally required, load shedding activities will continue to vary throughout the facility's remaining life as the oil, water and gas production profiles continue to vary due to reservoir performance.

In the event of total loss of power generation an uninterruptable power supply (UPS) provides electrical power to the safety instrumented system, fire and gas system, subsea control system and telecommunications system for a minimum of 60 minutes.

Back-up power generation and 'black start' capability is provided by three diesel generators. An emergency generator is also provided and sized to handle the electric load under emergency situations.

Battery backup systems are installed for supporting the following equipment:

+ Navigational Aids (Offshore marking light Morse code (U) for 96 hours);
+ Global Maritime Distress and Safety System;
+ Emergency lighting;
+ Emergency generator;
+ Firewater pumps (x2);
+ Rescue boat; and
+ Lifeboats (x2).

2.8.2 Lighting

Lighting is used for safe illumination of the FPSO work and accommodation areas and of other vessels during bunkering and supply activities. Lighting is kept on 24 hours a day for safety and navigational purposes in accordance with requirements of the Navigation Act 1912.

The main criterion for lighting design is to provide effective lighting to maintain a safe working areas, to allow personnel to move safely around the FPSO, to enable start-up, inspection and testing. All access ways to emergency pathways are also required to have sufficient lighting for successful evacuation from the ship in the event of an incident. The FPSO design considered minimising light spill while meeting personnel safety requirements.

2.8.3 Process Cooling and Heating

2.8.3.1 Cooling System

The cooling system on the FPSO uses a combination of seawater and freshwater cooling systems.

Closed loop fresh water and open loop seawater cooling systems are used for facility propulsion, production, heat exchangers and utility systems.

Seawater is utilised as the heat exchange medium in numerous heat exchangers for the propulsion, production and utility systems.

The seawater utilised in cooling services is discharged from the FPSO both on a continuous and on an intermittent basis. The combined discharge rate will vary depending on operational requirements.

The maximum discharge from the continuous sources is approximately 8,000 m^3/hr (192,000 m^3/day); based on design specifications, but the exact volume discharged will vary based on operational requirements and will typically be less.

2.8.3.2 Heating System

Heating systems required for the process and for the crude storage tanks are:

- Process – low pressure steam in heat exchangers; and
- Tanks – slops and selected cargo tanks.

The steam generation systems on the FPSO consist of two dual fuel (marine diesel or produced gas) water tube type boilers, and a low-pressure steam generator utilising steam from the fuel fired boilers as the heating medium.

2.8.4 Inert Gas and Cargo Venting

An inert gas system derived from boiler flue gas is provided on the FPSO for blanketing and displacing air in the crude oil cargo and slops tanks. The inert gas system utilises a dual main line system to allow for tank purging and oxygenating (for inspection purposes when empty) while other tanks are in service.

A gas vent riser outlet is located above the main deck flare tower to allow venting to be carried out when required. Intermittent discharge of inert gas to the atmosphere occurs from the vents as each of the tanks is progressively filled.

2.8.5 Nitrogen System

The FPSO is equipped with a nitrogen generation system and is used for purging process equipment, topsides piping and subsea infrastructure.

2.8.6 Fresh Water Production

Distilled water for boiler feed and domestic use is produced in freshwater generators installed in the engine room.

The generators convert seawater to fresh water with resulting brine, discharged to the marine environment. The discharge points to the ocean are located in the engine room. The desalination generators are treated with a small quantity of anti-scale chemicals to prevent scale build-up in the system.

2.8.7 Hydraulic and Lube Oil

The Hydraulic Power Units (HPUs) on the FPSO provide hydraulic fluids at various flow rates and pressures to accommodate the operational requirements of the equipment such as:

- Well subsurface safety valves and Xmas tree valves;
- Riser and fluid transfer path ESDVs;
- Topsides hydraulic ESDVs;
- Ancillary topsides and hull systems hydraulically actuated valves;
- Mooring buoy structural connectors;
- Cargo, ballast and slops tank valves; and
- Hull systems mooring and hawser winches.

2.8.8 Drainage System

The FPSO has a closed and open drainage system for collecting, handling, and treating drainage from the open deck and from topsides processing equipment, respectively.

2.8.8.1 Closed Drain System

The closed drain system is designed to collect hydrocarbon liquids drained from pressurised topsides equipment and transfer the recovered hydrocarbons back to the process system through the slops tank for re-processing.

2.8.8.2 Open Drain System

The open drains consist of the non-hazardous and hazardous drainage systems. Detailed below:

- The non-hazardous drainage system collects surface runoff (washdown water, sea water spray and rainwater) from the open deck areas of the FPSO. Scupper plugs are fitted at all overboard drainage points. If clean water builds up after for example heavy rain these plugs are manually removed allowing the clean water to drain to sea. Deck bilge pumps are provided to pump the main deck into the slops if the liquid is contaminated.
- The hazardous drainage system collects liquids from process module drains and equipment drip pans and directs it to the slops tank.

2.8.8.3 Other Drains

The water drains that collect in the bow chain locker and bosun store are periodically discharged overboard via eductors. This is a manual operation. Surface drains from the helideck flow directly overboard.

2.8.8.4 Bilges

The FPSO uses the existing tanker bilge system in the engine room and steering gear room, which consists of a number of scupper drains to drain oily water from engine room equipment and tank drip trays. Oily water that collects in the bilge wells is pumped to the bilge holding tank which is then periodically pumped to the slops tank. Oily drains in the engine room and steering gear room directly lead to oil-collecting tanks that are pumped to the slops tank via the bilge transfer pump.

Liquids in these systems are predominantly water but can contain small quantities of lube oil, cleaning chemicals and other products used within the engine room.

Emergency bilge injection is available via the high capacity main sea water cooling pumps which discharge directly to sea in case of significant flooding which could lead to loss of the vessel stability.

Bilges from the seawater pump room and the forward void space are pumped via a dedicated bilge header to the slop tanks. Bilges in the cargo pump room are pumped to the slop tanks.

2.8.8.5 Slops System

The FPSO has two slops tanks, port and starboard. They are for receiving:

- Off-specification PW;
- Oil; and
- Drainage from open and closed drains.

The slops tanks are treated by the following:

- Re-heating; and
- Chemical treatment (if slops inventories remains for any length of time in the tank biocide is required to minimise sulphur reducing bacteria activity, which can cause significant corrosion issues).

Slops contents can be rerouted for re-processing via the main production process or to an offtake tanker. Slops tanks are never directly discharged to the marine environment.

2.8.9 Chemicals

2.8.9.1 Production Chemicals

Various production chemicals are injected in the FPSO topsides and subsea systems.

Bulk chemicals are delivered to the FPSO in transportable containers by support vessels. The transportable containers are lifted onto the topsides and stored in bunded laydown areas. Chemicals are pumped from containers, as required, to the FPSO storage tanks through dedicated transfer lines. The chemicals are pumped from the storage tanks to injection points by injection pumps.

Methanol is injected into the topsides and subsea infrastructure for activities such as:

- Well start-up;
- Inhibition;
- During process upsets; and
- Pressure and leak testing.

Activities such as pressure and leak testing may result in the discharge of residual methanol to the marine environment. A non-toxic dye may also be used to assist in the visual detection of leaks in the subsea system.

The topsides and subsea infrastructure is periodically flushed as part of IMMR activities (See **Section 2.13**) with flushing agents such as:

- MEG;
- Methanol;
- Diesel Biocide Additive;
- Inert gasses; and
- Inorganic and organic acids.

Section 2.13 provides details on discharges to the marine environment from IMMR activities.

Production chemicals are soluble in PW to varying extents and the dissolved fractions may be present within the PW. **Section 6.7** provides details production chemicals within the PW.

2.8.9.2 Other Chemicals

Other chemicals stored on the FPSO are:

- Degreaser;
- Boiler chemicals;
- Solvents, paints, and oils (for maintenance);
- Cleaning chemicals; and
- Foam (for firefighting) – Aqueous Film Forming Foam (AFFF).

Radioactive sources are encased in the subsea multiphase flow meters and in fixed density gauges on board the vessel (inside the separators).

Laboratory chemicals are used in low quantities and stored in the laboratory. In general, laboratory chemicals are diluted and diverted to the slops tanks for treatment.

2.8.9.3 Chemical Assessment

A risk-based approach to select chemical products ranked under the Offshore Chemical Notification Scheme (OCNS) is applied for those chemicals used and discharged to the marine environment. This scheme lists and ranks all chemicals used in the exploration, exploitation, and associated offshore processing of petroleum on the UK Continental Shelf.

Chemicals are ranked according to their calculated Hazard Quotients (HQ) by the CHARM (Chemical Hazard Assessment and Risk Management) mathematical model, which uses aquatic toxicity, biodegradation and bioaccumulation data. The HQ is converted to a colour banding with Gold and Silver colour bands representing the least environmentally hazardous chemicals. Chemicals not amenable to the CHARM model (i.e. inorganic substances, hydraulic fluids or chemicals used only in pipelines) are assigned an OCNS grouping based on the worst-case ecotoxicity data with Group E and D representing the least hazard potential.

The Santos *Operations Chemical Selection, Evaluation and Approval Procedure* (EA-91-II-10001) accepts CHARM ranked Gold/Silver, or non-CHARM ranked E/D chemicals for use and discharge without a detailed environmental risk assessment. The same applies to chemicals that are OSPAR Pose Little or No Risk to the Environment (PLONOR) List. The PLONOR Listed, agreed upon by the OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic), contains a list of substances that will pose little or no risk to the environment in offshore waters. If chemicals are ranked lower than Gold, Silver, E or D (i.e. CHARM ranked purple, orange, blue or white, or non-CHARM A, B or C ranked chemicals) and no alternatives are available, a risk assessment is conducted providing technical justification for their use, and showing that their use and associated risk is acceptable and ALARP.

As described above, investigation of potential alternative chemicals are completed when chemicals are ranked lower than CHARM Gold, Silver, E or D (i.e. CHARM ranked purple, orange, blue or white, or non-CHARM A, B or C ranked chemicals). There is a preference for chemical options that are CHARM ranked Gold/Silver, or non-CHARM ranked E/D chemicals and / or chemical that have a low aquatic toxicity, are readily biodegradable and do not bioaccumulate (discussed below).

Any chemicals that may be discharged to the marine environment and not OCNS CHARM or non-CHARM ranked are risk assessed using the OCNS CHARM or non-CHARM models. The chemical is assigned a pseudo-ranking based on the available aquatic toxicity, biodegradation and bioaccumulation data (discussed below) and assessed for environmental acceptability for discharge to the marine environment.

Ecotoxicity Assessment

Table 2.4 and **Table 2.5** act as guidance in assessing the ecotoxicity of chemicals during the investigation of potential alternatives. **Table 2.4** is used by Cefas to group a chemical based on ecotoxicity results, 'A' representing highest toxicity/risk to environment and 'E' lowest. **Table 2.5** shows classifications/categories of toxicity against aquatic toxicity results.

Table 2.4: Initial OCNS grouping

Initial grouping	A	B	C	D	E
Result for aquatic-toxicity data (ppm)	<1	≥1-10	>10-100	>100-1,000	>1,000
Result for sediment-toxicity data (ppm)	<10	≥10-100	>100-1,000	>1,000-10,000	>10,000

Note: Aquatic toxicity refers to the Skeletonema costatum EC50, Acartia tonsa LC50, and Scophthalmus maximus (juvenile turbot) LC_{50} toxicity tests. Sediment toxicity refers to the Corophium volutator LC_{50} test.
Source: Cefas Standard Procedure 2019, OCNS 011 NL Protocol PART 1: Core Elements

Table 2.5: Aquatic Species Toxicity Grouping

Category	Species	LC_{50} and EC_{50} criteria
Category Acute 1 Hazard statement - Very toxic to aquatic life	Fish	LC_{50} (96hr) of ≤1 mg/L
	Crustacea	EC_{50} (48hr) of ≤1 mg/L
	Algae / other aquatic plant species	ErC_{50} (72 or 96hr) of ≤1 mg/L
Category Acute 2 – Hazard statement – Toxic to aquatic life	Fish	LC_{50} (96hr) of >1 mg/L to ≤10 mg/L
	Crustacea	EC_{50} (48hr) of >1 mg/L to ≤10 mg/L
	Algae / other aquatic plant species	ErC_{50} (72 or 96hr) of >1 mg/L to ≤10 mg/L
Category Acute 3 – Hazard statement – Harmful to aquatic life	Fish	LC_{50} (96hr) of >10 mg/L to ≤100 mg/L
	Crustacea	EC_{50} (48hr) of >10 mg/L to ≤100 mg/L
	Algae / other aquatic plant species	ErC_{50} (72 or 96hr) of >10 mg/L to ≤100 mg/L

Source: United Nations (2019) Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Eight Revised Edition

Biodegradation Assessment

The biodegradation of chemicals is assessed using the Cefas biodegradation criteria, which aligns with the categorisation outlined in the United Nations GHS Annex 9 Guidance on Hazards to the Aquatic Environment (2019). The below is used as a guide during the investigation of potential chemical alternatives. Preference is to select readily biodegradable chemicals.

Cefas categorises biodegradation into the following groups:

+ Readily biodegradable: results of >X% biodegradation in 28 days to an OSPAR harmonised offshore chemical notification format (HOCNF) accepted ready biodegradation protocol.
+ Moderately biodegradable: results >20% and <X% to an OSPAR HOCNF accepted ready biodegradation protocol.
+ Poorly biodegradable: results from OSPAR HOCNF accepted ready biodegradation protocol

Where X is equal to:

  + 60% in 28 days in OECD 306, Marine BODIS or any other acceptable marine protocols, or in the absence of valid results for such tests.
  + 60% in 28 days (OECD 301B, 301C, 301D, 301F, Freshwater BODIS) OR
  + 70% in 28 days (OECD 301A, 301E).

Bioaccumulation Assessment

The bioaccumulation of chemicals is assessed using the Cefas bioaccumulation criteria, which aligns with the categorisation outlined in the United Nations GHS Annex 9 Guidance on Hazards to the Aquatic Environment (2019). Preference is to select non bioaccumulative chemicals.

The following guidance is used by Cefas:

+ Non-bioaccumulative/non-bioaccumulating: Log P_{ow} <3, or results from a bioaccumulation test (preferably using *Mytilus edulis*) demonstrates a satisfactory rate of uptake and depuration, and the molecular mass is ≥700.
+ Bioaccumulative/Bioaccumulates: Log P_{ow} ≥3, or results from a bioaccumulation test (preferably using *Mytilus edulis*) demonstrates an unsatisfactory rate of uptake and depuration, and the molecular mass is <700.

All operational chemicals will be selected in accordance with the Santos *Operations Chemical Selection, Evaluation and Approval Procedure* (EA-91-II-10001).

2.8.10 Waste Storage and Disposal

Solid and liquid wastes produced on the FPSO are segregated, stored, and transferred to the mainland for final treatment and disposal at licensed waste disposal facilities if they cannot be treated and disposed of through the production system (e.g. liquid hydrocarbon wastes and produced formation water) or onboard disposal systems (e.g. cooling water, grey and treated black water, putrescible wastes).

Waste storage includes a range of facilities such as covered waste skips and onboard dedicated holding tanks or drums. Hazardous wastes such as paint wastes, oily rags, Naturally occurring radioactive materials (NORMs) contaminated materials are segregated from other waste streams. All waste materials offloaded are documented and tracked.

Trace amounts of NORMs have been detected in reservoir sands, collected within the desander unit on board the FPSO.

Oil contaminated sand and fines collected in the topsides equipment and oil cargo tanks is separated and stored in suitable containers on the FPSO and transported onshore for appropriate treatment or disposal.

2.8.11 Fire and Gas Detection and Fire Fighting Equipment

Fire and gas detection, AFFF fire fighting systems are available on the FPSO for emergency purposes. Routine and contingency testing of the systems and the AFFF is undertaken and is critical for emergency response preparedness.

2.8.12 Putrescible Waste and Sewage Treatment

The volume of putrescible waste (food waste) and sewage is directly proportional to the Persons On Board (POB) of the FPSO. Putrescible waste and sewage are treated on the FPSO prior to discharge to the marine environment.

2.9 Operational Support Activities

2.9.1 Offtake Operations

Crude offtake operations take place depending on production rates (approximately monthly). The maximum offloading parcel size is 530,000 bbl, which can take approximately a week to offtake, excluding mooring and disconnection time of the offtake tanker. At least one support vessel is on location providing static tow of the offtake tanker and assisting in hook-up and disconnect.

During offtake operations, seawater may be taken onboard into segregated sweater ballast tanks to maintain FPSO stability and hull stresses within acceptable limits.

Offtake tankers are third party vessels and are vetted against agreed criteria and Oil Companies International Marine Forum (OCIMF) guidelines prior to acceptance for lifting product from the NV Operations. The use of tankers with double hulls and fully segregated ballast tanks is not only a requirement of the vetting process, it is also a MARPOL requirement that is monitored by way of regular statutory inspections.

Offtake tankers may be fuelled by HFO. A combined typical maximum HFO inventory of 1,900 m^3 exists in the offtake tanker HFO tanks, with the largest HFO tank having a capacity of 950 m^3.

The offtake tanker operations are considered a Petroleum Activity under the OPGGS Act and within the scope of this EP only whilst connected and carrying out a crude offtake.

2.9.2 Refuelling

Marine diesel oil (MDO) is required as the primary fuel for the following:

+ FPSO's main engine;
+ Essential generators;
+ Emergency generator;
+ Firewater pumps;
+ Lifeboats;
+ Temporary equipment;
+ Cargo pumps; and
+ Rescue craft.

MDO is utilised as a secondary fuel for the following dual fuel system:

+ Boilers when produced gas is unavailable on the FPSO.

MDO is bunkered onboard the FPSO from support vessels and stored in diesel tanks located internally within the FPSO hull.

2.10 Vessel Operations

Vessels are typically locally sourced from the northwest shelf (NWS) region. Vessels are vetted by Santos to ensure appropriateness for the required activities and typically fall into two categories:

+ Support vessels (**Section 2.10.1**) – for day-to-day operation and routine IMMR activities; and
+ Project vessels (**Section 2.10.2**) – for specific project/campaign type activities.

Given the depth of the operational area, all vessels will operate on Dynamic Positioning (DP) negating any requirement to anchor.

2.10.1 Support Vessels

Vessel support activities are undertaken to support the efficient day-to-day operation of the FPSO. The FPSO has typically been supported by vessels such as the Mermaid Cove or Toll Provider, operating out of Exmouth. However, from time to time depending on operational requirements other support vessels may be used. Anticipated, typical support vessel parameters are provided in **Table 2-6**.

Table 2-6: Typical Support Vessel Parameters

Parameter	Description
Draft (max)	4.9 m (max)
Gross tonnage	1386 Gt
Hull	Steel hull
Fuel type	Marine diesel
Total fuel volume	592.5 m^3
Volume of largest fuel tank	329 m^3
Persons on Board (POB)	22

Support vessels provide support activities to the FPSO during operations, including:

+ Transportation of materials, fuel (MDO for refuelling of the FPSO) and chemicals (**Section 2.8.9**);
+ Backload any equipment, waste, materials;
+ Offtake operations (**Section 2.9.1**) support; and
+ FPSO reconnection to DTM support (**Section 2.4**).

2.10.2 Project Vessels

IMMR activities (**Section 2.13**) and hook-up and commissioning activities (**Section 2.14**) may require project specific vessels. These may be chosen specifically for the technical requirements of the project. Typically, these vessels will be of similar parameter to those shown in **Table 2-7.**

Table 2-7: Typical Project Vessel Parameters

Parameter	Description
Draft (max)	7.2 m (max)
Gross tonnage	6200 Gt (max)
Hull	Steel hull
Fuel type	Marine diesel
Total fuel volume	2500 m^3 (max)
Volume of largest fuel tank	329 m^3
Persons On Board (POB)	120 (max)

2.11 Helicopter Support

Helicopters are used primarily for crew change and typically operate out of Exmouth, with trips to the FPSO occurring on average twice a week, dependent on operational requirements.

2.12 Unmanned Aerial Vehicles

The exterior of the FPSO may be inspected using Unmanned Aerial Vehicles (UAVs). UAVs may be used to conduct aerial surveys within the operational area. UAVs are autonomous aircraft that will use the FPSO or a vessel as a launch platform to execute surveys and inspections to inform the Computerized Maintenance Management System (CMMS).

2.13 Subsea and Seabed IMMR activities

Operational IMMR conducted by Remotely Operated Vehicle (ROV), Autonomous underwater vehicle (AUV) or diver, may include:

+ Post cyclone survey;
+ Subsea infrastructure inspections and cleaning;
+ Replacement / repair of subsea equipment / components; and
+ Minor stabilisation of subsea infrastructure.

IMMR typically involves assistance from one or two vessels that have dynamic positioning capabilities. Details of the above, including typical equipment required and discharges are presented in **Table 2-8**.

Table 2-8: Subsea and Seabed IMMR Activities and Associated Activity Discharges

Activity	Details	Equipment / example activity	Typical chemical use and discharge to marine environment
Post cyclone survey	+ Inspection of subsea infrastructure post cyclone	+ ROV or diver visual inspection	+ No planned discharge
Subsea infrastructure inspection and cleaning	+ Inspection of subsea infrastructure including moorings. + Inspection of hull / DTM	+ ROV and tooling + AUV + Water jetting + Mechanical brushing + Chemical soaking + Diver inspection + Marine growth removal + Side Scan Sonar + beam echo sounder + Multibeam imaging sonar + Non-contact and contact Cathodic protection checks + Non-destructive testing	+ Marine growth
Replacement, maintenance and repair of subsea equipment components	+ Repair of hull / DTM subsea valve manipulations + Subsea control system operation and repair + Replacement of flowlines / umbilicals + Subsea manifold test and valve operations	+ ROV and tooling + AUV + Water jetting + Mechanical brushing + Diver visual inspection + Marine growth removal + Side Scan Sonar	+ Organic acids + Methanol + MEG + Non-toxic dye + Water based hydraulic fluid / subsea control fluid + Hydrocarbon gas

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Activity	Details	Equipment / example activity	Typical chemical use and discharge to marine environment
		+ Multibeam imaging sonar + Non-contact and contact Cathodic protection checks + Non-destructive testing + Running tools for hardware replacement + Acid injection equipment	+ Treated seawater with MEG, biocide, oxygen scavenger, corrosion inhibitor and non-toxic dye + Residual hydrocarbon and inert gas
Stabilisation of subsea infrastructure	+ Placement of gravel and grout bags	+ Gravel and grout bags, mattress etc. + ROV and tooling + AUV + Vessel + Localised seabed excavation around structures	+ N/A

2.13.1 Subsea Infrastructure Inspection and Surveys

Offshore external inspection requirements of all NV Operations subsea infrastructure is outlined in the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007). Whilst the EP includes provision for inspection, maintenance, monitoring and repair, the term is called IMM here, consistent with the contents of the IMM Plan. This plan covers inspection scopes and IMM frequencies for all subsea infrastructure, including:

+ Flexible risers and flexible riser diver less bend stiffener connector (DBSC)
+ Mooring system
+ DTM
+ Flexible flowlines
+ Gas lift jumpers
+ Umbilicals
+ Manifold
+ Trees
+ Rigid Spools
+ Electric Flying Leads (EFLs), Hydraulic Flying Leads (HFLs) and Subsea Distribution Unit (SDUs)

IMMR frequencies are set for GVI (General Visual Inspection) and CP (Cathodic Protection) monitoring within the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007). Frequencies are nominally set for all subsea infrastructure, except the hydrocarbon containment elements of the subsea production system, which have an annual GVI commitment. Note that due to the nature of offshore campaigns, this annual GVI scope for hydrocarbon containment equipment and conduits may be performed over a number of offshore campaigns in any given calendar year (**Table 2-9**).

Table 2-9: IMM frequencies

Hydrocarbon Containing Component	GVI	CP
Flexible risers [3]	Annual [5]	3 years
Manifold	Annual [5]	3 years
Trees	Annual [5]	4 years
Rigid Spools	Annual [5]	4 years
Gas lift jumpers	Annual [5]	-
Non- hydrocarbon Containing Component	**GVI**	**CP**
Umbilicals	3 years	3 years
Flexible riser diverless bend stiffener connector (DBSC)	2 years [4]	3 years
Mooring system	5 years	5 years
DTM	5 years	3 years
EFLs, HFLs and SDUs [2]	3 years	3 years

Note 1: Inspection frequency for dynamic umbilicals only
Note 2: Inspection frequency for SDU structures only
Note 3: Riser vacuum testing and borescope inspection performed 2 yearly
Note 4: Inspection of the DBSCs are performed 2 yearly / post disconnect DTM inspection, whichever is sooner
Note 5: Set frequency, GVI of hydrocarbon subsea system and structures committed to occur annually (may occur over more than one offshore campaign)

Actual IMMR frequencies and intervals for the NV subsea infrastructure are determined on the basis of a risk assessment process. The risk assessment typically utilises the following to determine IMMR frequency:

- Historical IMMR information acquired through inspection / monitoring / repair
- New equipment tied back to the asset
- Nominal inspection frequencies set within the IMM Plan.

GVI of the hydrocarbon containment elements of the subsea production system, is committed to occur annually and this minimum frequency is irrespective of the risk assessment.

The findings of the IMMR campaigns may change the future frequencies of the IMMR activities if anomalies are identified.

Additional inspections may be performed following significant external events (e.g. extreme weather, sea conditions, third-party interactions), integrity assessments or other triggers that indicate further inspection is required. Post-cyclone inspection by ROV may be able to provide additional surveillance of anomalies or areas of interest flagged by inspections or analysis.

IMMR typically includes:

- General Visual Inspection (GVI) / Close Visual Inspection (CVI). Items for inspection typically include:
  - General inspection of all equipment
  - Integrity of the flowline system including all sub-components
  - Location of all features detailed on alignment sheets or as-built records
  - Seabed topography, flowline / subsea structure settlement and extent of burial
  - Dents, gouges or corrosion defects
  - Leaks or bubbles
  - Mechanical damage
  - Coating condition (where visible)
  - Marine growth and thickness
  - Anode condition
  - Condition of continuity straps
  - Scour
  - Debris or foreign objects
  - Excessive pipe movements including expansion effects
  - Flowline protection, stabilisation and scour remediation.
- Cathodic Protection (CP) Survey, typically including logging of:
  - The subsea equipment, date of readings and position of anodes
  - Digital potential reading of the surveyed area
  - Condition of anodes and wastage (%)
  - Any anomalous observations or missing anodes.

Maintenance activities may include corrective (e.g. replacement, maintenance and repair of subsea equipment components, see **Table 2.8**) and non-routine maintenance, undertaken in accordance with routine or corrective work orders and detailed in CMMS.

IMMR, including surveys, may utilise the following equipment:

+ Multi-beam echo sounder (MBES);
+ Side Scan Sonar (SSS);
+ ROV;
+ AUV; and
+ Non-contact and contact cathodic protection checks.

ROV surveys utilise a small submersible vehicle that captures and transmits streaming video back to a vessel and may be fitted with a SSS and MBES which are common offshore surveying tools. ROVs are remotely controlled from on-board a vessel (e.g. dynamically positioned vessel or FPSO) via an umbilical cable. This type of survey is used for routine inspections of pipeline bundles, subsea valves, pipeline alignment surveys and subsea infrastructure inspections. ROV intervention might also occur to carry out minor repairs such as change out or replacement of subsea hydraulic control modules, production choke insert replacement, or electro-hydraulic/gas lift jumper replacement. These activities generally require partial or full field shutdown. In some instances, the ROV may be placed on the seabed.

AUVs may also be used to conduct geophysical and inspection activities, including sub-bottom profiles; MBES; SSS; cameras; and conductivity, temperature, and depth (CTD) profilers. AUVs travel underwater on a predefined ‘flight path’ without requiring navigation from an operator and are fitted with various payloads for data acquisition.

The size of the vessel required to deploy an ROV and/or AUV depends on the size of the ROV and/or AUV and the launch and recovery system. The AUV and/or ROV is typically deployed from a vessel using a crane or an A-frame and is recovered using a winch or net.

Diver assisted works, if required, are carried out for IMMR activities on the FPSO or the DTM buoy and risers. Diver assisted inspections are carried out by qualified commercial divers from a diving support vessel or from the FPSO.

Non-contact and contact CP checks are typically made using ROV. CP is required for all CP protected systems including risers, flowlines, rigid spools, umbilical end fittings and subsea structures to ensure CP potentials are sufficient to prevent corrosion.

It is through the implementation of this IMMR regime that Santos will meet its obligations under the OPGGS Act (s.572(2)) to ‘maintain in good condition and repair all structures that are, and all equipment and other property that is, in the title area and used in connection with the operations’

2.13.2 Marine Growth Removal

Marine growth on the subsea infrastructure (e.g. FPSO, DTM, riser flowlines and upper sections of the mooring lines) must be maintained at levels that do not compromise the structural integrity. The subsea infrastructure provides attachment points for a variety of marine organisms that over time add significantly to the drag and weight on the structure. Marine growth on the subsea infrastructure is inspected in accordance with the Subsea Inspection Procedure (QE-35-IS-00001) using ROV and/or divers; if determined to be beyond the allocated depth, marine growth is periodically removed. This is carried out on an as-required basis.

As part of ongoing maintenance and to facilitate inspections, the removal of marine growth may be required. Marine growth is regularly monitored against design limits. Removal of marine growth is typically only required for inspection purposes and is conducted on localised areas using high-pressure water cleaning or brushing or a combination of these:

- Water-jetting – conducted by ROV or divers, water is pressurised to above hydrostatic pressure. Generally, water-jetting activities are through small diameter water jets that act locally on the pipe/structure. Wash out or induced currents are typically not experienced during this activity due to the nature of the operation;
- Soaking – using approved chemical to soak infrastructure to remove marine growth (i.e. calciferous growths) if mechanical removal means are ineffective; and
- Mechanical brushing – typically a coarse brush would be applied to the structure on a localised area only.

2.13.3 Stabilisation of Subsea Infrastructure

Gravel / grout bags and concrete mattresses are placed on specific areas of the subsea infrastructure showing scour or movement and may also be used as subsea markers. The exact details and requirements are made post inspection and surveys.

2.14 Hook-up and Commissioning Activities

Any future drilling of wells (production, gas and water reinjection) within the Van Gogh/ Coniston/ Novara fields, hook-up and installation of associated subsea infrastructure will be covered under separate EPs.

Preparation for future tie-ins and subsequent commissioning (i.e. the start-up of hydrocarbon production) is included in this EP. This typically involves the activities presented in **Table 2-10**:

Table 2-10: Typical Commissioning Activities

Activity	Typical chemical use
ROV operations on subsea infrastructure	+ No planned discharge
Subsea valve operation	+ Residual discharge from valves (water-based hydraulic fluids)
Flushing and priming activities on subsea infrastructure	+ Chemicals from flushing are flowed to the FPSO for treatment and disposal, including chemicals such as: 1. MEG; 2. Diesel; and 3. Inert gasses;
Cleaning / soaking subsea infrastructure	+ Organic / in organic acids
Hydrotesting	+ Treated seawater discharge, including chemicals such as biocides and oxygen scavenger and methanol
De-watering and start-up	+ De-watering fluids, are flowed to the FPSO for clean-up and disposal

2.15 Suspension or Abandonment

During the field life, wells may become inactive and disconnected from the NV production system. However, permanent plug and abandon (P&A) of NV wells will require a mobile offshore drilling unit (MODU) and are not covered by this EP. Permanent well abandonment activities will commence within two years of field cessation of production activities or plugged and abandoned in accordance with the requirements of the NOPSEMA-approved Ningaloo Vision Well Operations Management Plan (WOMP) Revision 3.

2.16 Decommissioning

Santos' approach to asset life cycle management, including decommissioning, is described in **Section 8.8**. Santos does not currently have plans to decommission the NV facility within the five-year period of the EP. Cessation of operations is possible during the five year life of this EP. In that event the NV production system would be shut in and the FPSO would plan to leave the field, in a similar manner as for cyclone avoidance or to leave the field for maintenance activities (e.g. shipyard campaigns) (Section **2.5.1.1**).

Santos will ensure through monitoring, and maintenance if required, that property can be removed when required, and the ongoing presence of the property is not causing unacceptable environmental impacts or risks.

Monitoring and maintenance activities, as relevant to the point of decommissioning, are described in **Section 2.13**.

3 Environmental Description

OPGGS(E)R 2009 Requirements
Regulation 13. Environmental Assessment
Description of the environment 13(2) The environment plan must: (a) describe the existing environment that may be affected by the activity; and (b) include details of the particular relevant values and sensitivities (if any) of that environment. Note: The definition of *environment* in regulation 4 includes its social, economic and cultural features. 13(3) Without limiting paragraph (2)(b), particular relevant values and sensitivities may include any of the following: (a) the world heritage values of a declared World Heritage property within the meaning of the EPBC Act; (b) the national heritage values of a National Heritage place within the meaning of that Act; (c) the ecological character of a declared Ramsar wetland within the meaning of that Act; (d) the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act; (e) the presence of a listed migratory species within the meaning of that Act; (f) any values and sensitivities that exist in, or in relation to, part or all of: (i) a Commonwealth marine area within the meaning of that Act; or (ii) Commonwealth land within the meaning of that Act.

3.1 Environment That May Be Affected (EMBA)

This section summarises the key physical, biological, socio-economic and cultural characteristics of the existing environment that may be affected by the activity, both from planned and unplanned events associated with the activity. The description of the environment applies to three areas:

+ The operational area (see **Section 2.2**);
+ The PW mixing zone (See **Section 6.7**), noting this mixing zone is located within the operational area; and
+ The area that may be affected (EMBA), shown in **Figure 3-1.**

A detailed and comprehensive description of the environment (required by OPGGS(E)R 2009, Section13(3)) in the operational area and broader EMBA is provided in **Section 3** and **Appendix D**. Copies of the Department of the Environment and Energy (DoEE) (Now DoAWE) Protected Matters Search Tool outputs for the operational area and the EMBA are also available in **Appendix D**.

The EMBA encompasses the environment that could be affected by planned and unplanned events. Most planned and unplanned events associated with the NV Operations may affect the environment up to a few hundred metres from the NV FPSO. A large unplanned hydrocarbon spill would extend substantially beyond this.

3.1.1 Determining the Environment that May Be Affected

Stochastic hydrocarbon dispersion and fate modelling, applied to all credible spill scenarios identified as relevant to the NV Operations (**Section 7.5.1**), was undertaken to inform the EMBA (GHD, 2019) Stochastic modelling is created by overlaying hundreds of individual hypothetical oil spill simulations from an oil spill into a single map, with each simulation subject to a different set of metocean conditions drawn from historical records. Stochastic modelling is completed to reduce uncertainty in risk assessment and spill response planning.

The modelling considered four key physical or chemical phases of hydrocarbons that pose differing environmental and socioeconomic risks: surface, entrained (also referred to as total WAF), dissolved aromatic (also referred to as dissolved WAF) and shoreline accumulated hydrocarbons. The modelling used defined hydrocarbon exposure values, as relevant, to identifying an area that might be contacted by hydrocarbons, environment risk assessment and oil spill response planning, for the various hydrocarbon phases. Refer to **Table 3-1** for the exposure values used and to **Section 7.5.5** for further information on the reasons why these exposure values have been selected and how they relate to the risk assessments in **Section 7.6** to **Section 7.10**.

The EMBA is based on stochastic modelling, using the low exposure values (**Table 3-1**). The EMBA encompasses the outer most boundary of the overlaid worst-case spatial extent of the four hydrocarbon phases listed above for all of the credible spill scenarios. The EMBA is illustrated in **Figure 3-1**.

The low exposure values are used as a predictive tool to set the outer boundaries of an EMBA and may not necessarily result in ecologically significant impacts. To inform the evaluation of potential environmental consequences of a hydrocarbon release (impact assessment), modelling is undertaken using higher exposure values (i.e. the concentrations at which environmental consequences may result). The higher exposure values are known as 'moderate' and 'high' are described and explained **Section 7.5.5**. Applying the same method used to determine the EMBA, spatial areas were derived for moderate and high exposure values as illustrated on figures throughout **Section 3**.

While the EMBA represents the largest possible spatial extent that could be contacted by any of the worst-case spill events modelled, an actual spill event is more accurately represented by only one of the simulations from the stochastic modelling, resulting in a much smaller spatial footprint from an actual spill event. Modelling of a single simulation, representative of a single spill event is termed deterministic modelling. An example of a deterministic run (single is illustrated in **Figure 3-1** to demonstrate a more realistic spatial extent for the worst-case spill event (i.e. a deterministic EMBA – using low exposure values). The deterministic EMBA for this EP is a single simulation from the worst case scenario described in **Table 7-6**, which is a subsea release of hydrocarbons from a production well (**Section 7.6**).

Table 3-1: Hydrocarbon Exposure Values

Hydrocarbon phase	Exposure Value		
	Low	Moderate	High
Surface (g/m^2)	1	10	50
Shoreline accumulation (g/m^2)	10	100	1,000
Dissolved aromatics (ppb)	10	50	400
Entrained (ppb)	10	100	-

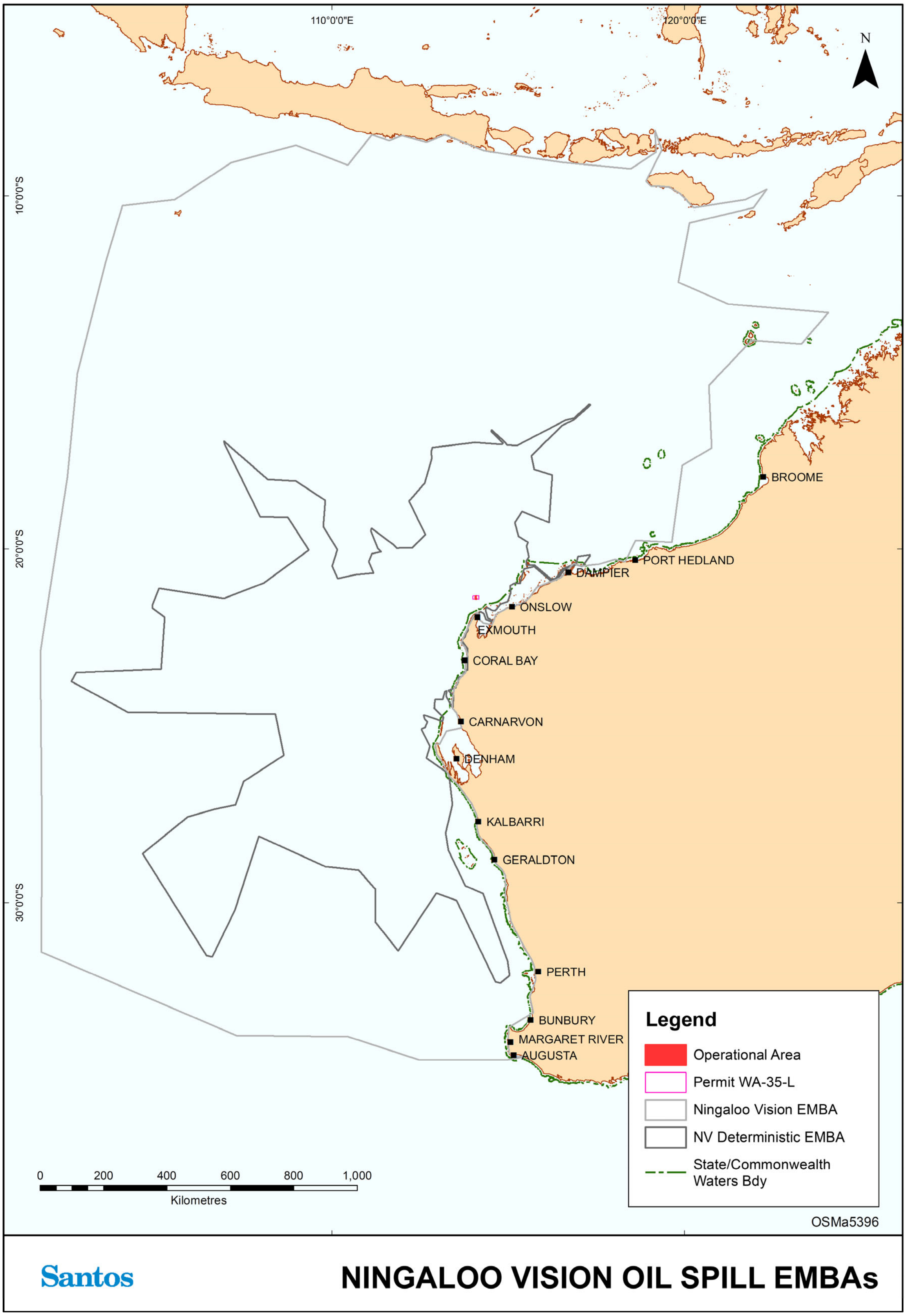


Figure 3-1: NV Oil Spill EMBA

3.2 Environmental Values and Sensitivities

This section summarises environmental values and sensitivities, including physical, biological, socio-economic and cultural features in the marine and coastal environment that are relevant to the operational area, PW impact area and the EMBA.

Desktop searches of the operational area, PW mixing zone and the EMBA were undertaken in January 2020 using the DoEE Protected Matters Search Tool for the purpose of identifying matters of national environmental significance listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). The results of these searches are provided summarised throughout this Section and **Appendix D**.

A comprehensive description of the environmental values and sensitivities present in the existing environment, operational area and EMBA is provided in this chapter and **Appendix D** (required by OPGGS(E)R 13(2)). This draws upon existing knowledge and a comprehensive review of information on the marine environmental values and sensitivities in the region.

3.2.1 Bioregions

The operational area is situated within Commonwealth waters of the North West Marine Region, 45 km north-northwest off the Cape Range Peninsula in Western Australia.

Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0, the operational area and PW mixing zone overlap the Northwest Province of the North-west Marine Region (**Figure 3.2).** The EMBA overlaps the North-west Marine Region and South-west Marine Region as well as extending to Timor Leste waters and Christmas Island. Provinces and bioregions relevant to the EMBA are:

North-west Marine Region:

+ Northwest Shelf Transition;
+ Timor Province;
+ Northwest Transition;
+ Northwest Province;
+ Northwest Shelf Province;
+ Central Western Transition;
+ Central Western Shelf Transition; and
+ Central Western Shelf Province.

South-west Marine Region:

+ Central Western Province;
+ Southwest Shelf Transition;
+ Southwest Transition;
+ Southwest Shelf Province; and
+ Southern Province.

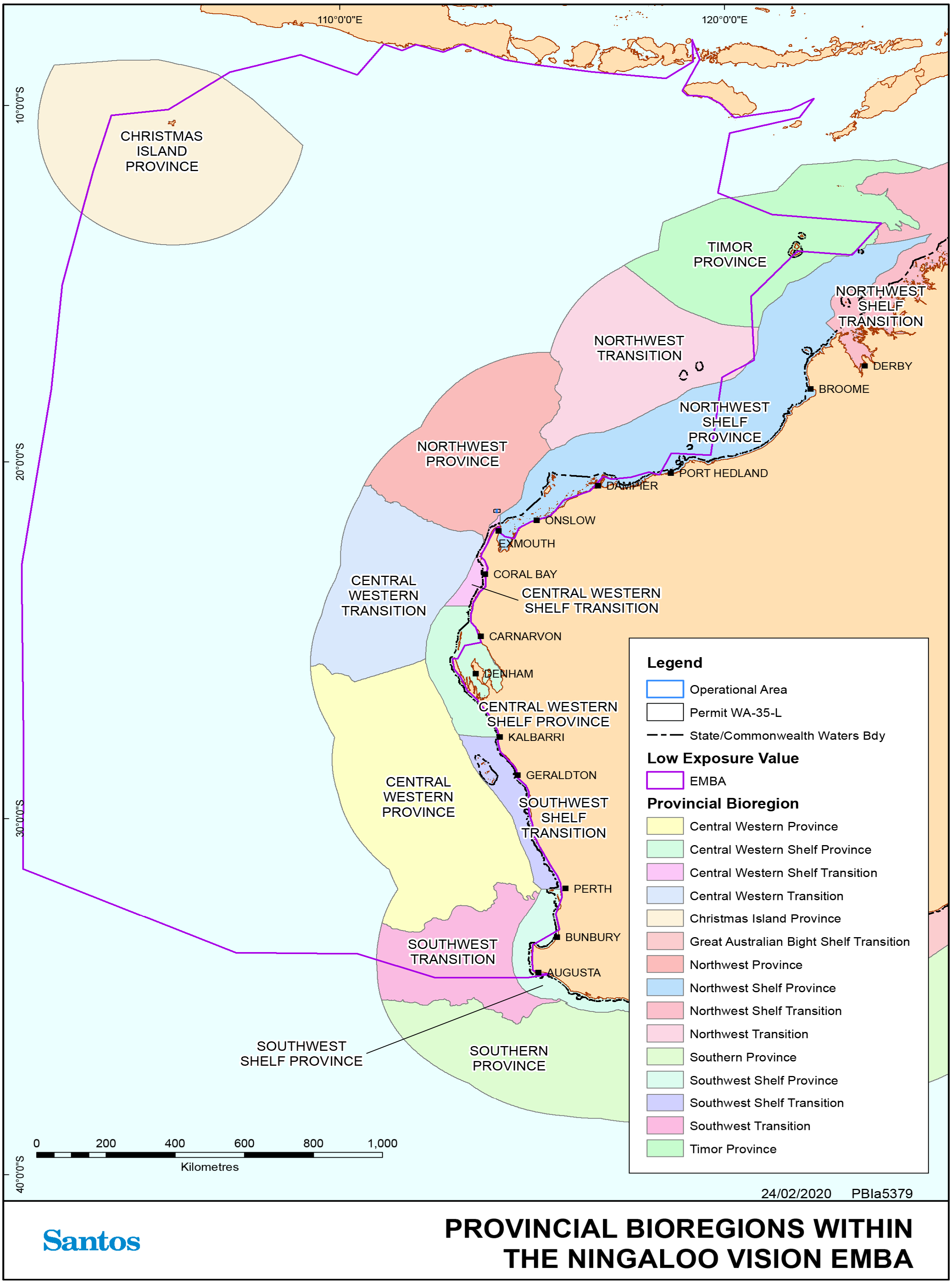


Figure 3-2: IMCRA 4.0 Provincial Bioregions within the EMBA and in Relation to the NV Operations

3.2.2 Benthic Habitats

3.2.2.1 Operational Area

The operational area does not contain any shoreline habitat. The operational areas is 45 km north-northwest off the Cape Range Peninsula in Western Australia.

Within the operational area and PW mixing zone, soft sediment is the dominant habitat. A survey of seabed habitat has previously been conducted at the Coniston/Novara fields (RPS, 2011a) and at the Van Gogh Field (Apache, 2009). The seabed survey at the Coniston/Novara fields, along the flowlines and production manifold locations, has revealed a flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (including anemones, sea stars, soft corals, crabs, shrimp and sea urchins) and an infaunal community dominated by polychaetes and crustaceans. This survey found no unique communities or communities of regional significance (RPS, 2011a). Similarly, a seabed survey at the Van Gogh field has revealed a flat substrate comprising mud and silts sediments with sparse epifauna (including sponges, echinoderms and crustaceans) and an infaunal community comprising mainly polychaetes and crustaceans (Apache, 2009).

The depth of the operational area and PW mixing zone (>300 m) precludes the existence of benthic primary producers (i.e. photosynthetic organisms including hard corals, seagrasses and macroalgae), which are typical of shallower coastal areas, as seabed light availability at these depths is insufficient to support photosynthesis.

3.2.2.2 EMBA

Table 3-2 summarises the habitats that may be impacted by routine events within the operational area as well as potential impacts from unplanned events within the larger EMBA. For each habitat the table provides links to relevant routine or unplanned events within **Sections 6** and **7** that may create an impact. The PW mixing zone has not been specifically referenced within this table, as habitats within this area are as per the operational area.

Impacts from unplanned events associated with NV Operations could occur within an area greater in size than the designated operational area. A number of hydrocarbon spill scenarios exist for the activity each with the corresponding EMBA derived from stochastic spill modelling (**Sections 7.6** to **7.10**). Benthic habitats identified from the EMBA, and from predictions of shoreline contact from spill modelling (GHD, 2019), include benthic primary producers (coral reefs, macroalgae, seagrasses and mangroves), soft sediments, rocky substrates, intertidal mud/sandflats, rocky shorelines and sandy beaches.

Within the EMBA, habitat diversity is highest in shallower waters (<30 m) associated with the mainland and offshore islands/shoals where light availability promotes the occurrence of benthic primary producers, and in areas where hard substrate provides attachment points for a greater diversity of habitat forming organisms. Within the EMBA benthic habitat diversity is therefore highest within waters along the Ningaloo coastline, shallow waters around offshore islands extending from North West Cape to Onslow (e.g. Muiron Islands) and the Montebello/Barrow/Lowendal Islands.

Benthic primary producers are important components of ecosystems as they provide the source of energy driving food webs, and provide shelter for a diverse array of organisms. Further information on benthic primary producers, identified as being present within EMBA, or identified from predictions of hydrocarbon shoreline contact, is presented under subheadings below.

A detailed description of the marine and coastal habitats within the EMBA are summarised with reference to the IMCRA provincial bioregions in the EE document.

Table 3-2: Habitats Associated with Receptors Identified within the EMBA

Receptors	Subtidal/Intertidal Habitats					Shoreline Habitats			Operational area	EMBA: All loss of containment scenarios			
	Soft Sediments	Coral Reefs	Macroalgal Beds	Seagrass Beds	Hard Substrate (Flora/Fauna)	Rocky Shorelines	Sandy Beaches	Mangroves		Surface Oil (1 g/m^2) Contact	Entrained hydrocarbon (10 ppb) Contact	Dissolved Aromatic Hydrocarbons (10 ppb) Contact	Shoreline accumulation (≥10 g/m^2) Contact
Dampier Archipelago	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
Northern, Middle and Southern Islands Coast (Onslow Region)	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
Montebello Islands	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
Lowendal Islands	✓	✓	✓	✓	×	✓	✓	×	×	✓	×	×	✓
Barrow Island	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	✓
Thevenard Islands	✓	✓	✓	✓	×	×	✓	x	×	✓	×	×	✓
Muiron Islands	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	×	✓
Exmouth Gulf Coast	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×	✓
Ningaloo Region	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Outer Shark Bay Coast	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	✓

Barrow-Montebello Surrounds	✓	✓	✓	✓	✓	×	×	×	×	✓	✓	×	×
Montebello AMP	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	×	×
Zuytdorp Cliffs - Kalbarri	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	✓
Shark Bay AMP	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×
Offshore Abrolhos NW	✓	✓	✓	✓	✓	×	×	×	×	×	✓	×	×
Port Hedland	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×
Kalbarri-Geraldton	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×
Rottnest Island	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×
Perth Southern Coast	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	×
Dawesville-Bunbury	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	✓
Geographe Bay	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	✓
Mandurah-Dawesville	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	×	✓
Roebuck-Eighty Mile Beach	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	✓
Jurien Bay- Yanchep	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	×	✓
Perth Northern Coast	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓	×	✓
Christmas Island	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	×	✓

3.2.3 Protected / Significant Areas

There are a number of Matters Protected under the EPBC Act that lie within the operational area, PW mixing zone and EMBA; these are listed in **Table 3-3** and further described in the EE (**Appendix D1**). A search of the EPBC Act Protected Matters Database was used to identify these matters based on the boundary coordinates of the operational area and EMBA.

The operational area and PW mixing zone do not intercept any marine protected areas, the closest to the operational area being the Ningaloo AMP and the Muiron Island Marine Management Area that are located approximately 27 km south and 32 km south east respectively of the operational area (**Table 3-3)**.

Two World Heritage Areas (WHA) were identified from the EPBC Protected Matters database as occurring within the EMBA, they are the Ningaloo Coast WHA and Shark Bay WHA. The values of these sites have been described in **Appendix D1**.

Three Ramsar sites overlap with the EMBA; The Dales, Hosnies Spring and the Peel Yalgorup System. They have been described in **Appendix D1.**

Five National Heritage properties, ranging from Natural, Indigenous and Historic, were identified from the EPBC Protected Matters database as occurring within the EMBA. Shark Bay and the Ningaloo Coast were identified as the natural National Heritage Properties; the indigenous National Heritage Property is the Dampier Archipelago (including Burrup Peninsula); and the historic National Heritage Properties were the Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos and Dirk Hartog Landing Site 1616 – Cape Inscription Area (**Table 3-3**). The values of these sites have been described in the EE.

The EMBA overlaps a number of Australian Marine Parks (AMPs) (**Section 3.2.3**) as well as State Marine Parks and Marine Management Areas (**Table 3-3)** These areas are further discussed in **Appendix D1.** AMPs and State Marine Parks and Marine Management Areas within the EMBA are presented in **Figure 3-3** A and B.

AMPs are recognised under the EPBC Act for protecting and maintaining biological diversity and contributing to a national representative network of marine protected areas. Management plans for AMPs have been developed and came into force on 1 July 2018. Under these plans AMPs are allocated conservation objectives (IUCN Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. The management zones, associated with the AMPs identified in the EMBA, and the relevant objectives are detailed in Table 3-4.

Key ecological features (KEFs) which are components of the marine ecosystem that are considered to be important for biodiversity or ecosystem function and integrity of the Commonwealth Marine Area are also included in the EPBC Act Protected Matters Database results (**Appendix D2 to D4**). The Continental Slope Demersal Fish Communities KEF overlaps the operational area and PW mixing zone. The EMBA also overlaps a number of KEFs. **Table 3-3** lists the KEFs in the EMBA, together with their distance from the operational area. Further detail on these KEFs are provided in **Appendix D1**.

Table 3-7 summarises the EPBC Act protected matters that may be affected by planned and unplanned events within the operational area, PW mixing zone and EMBA. For each protected matter the table provides links to relevant planned and unplanned events within **Sections 6** and **7** that may create an impact.

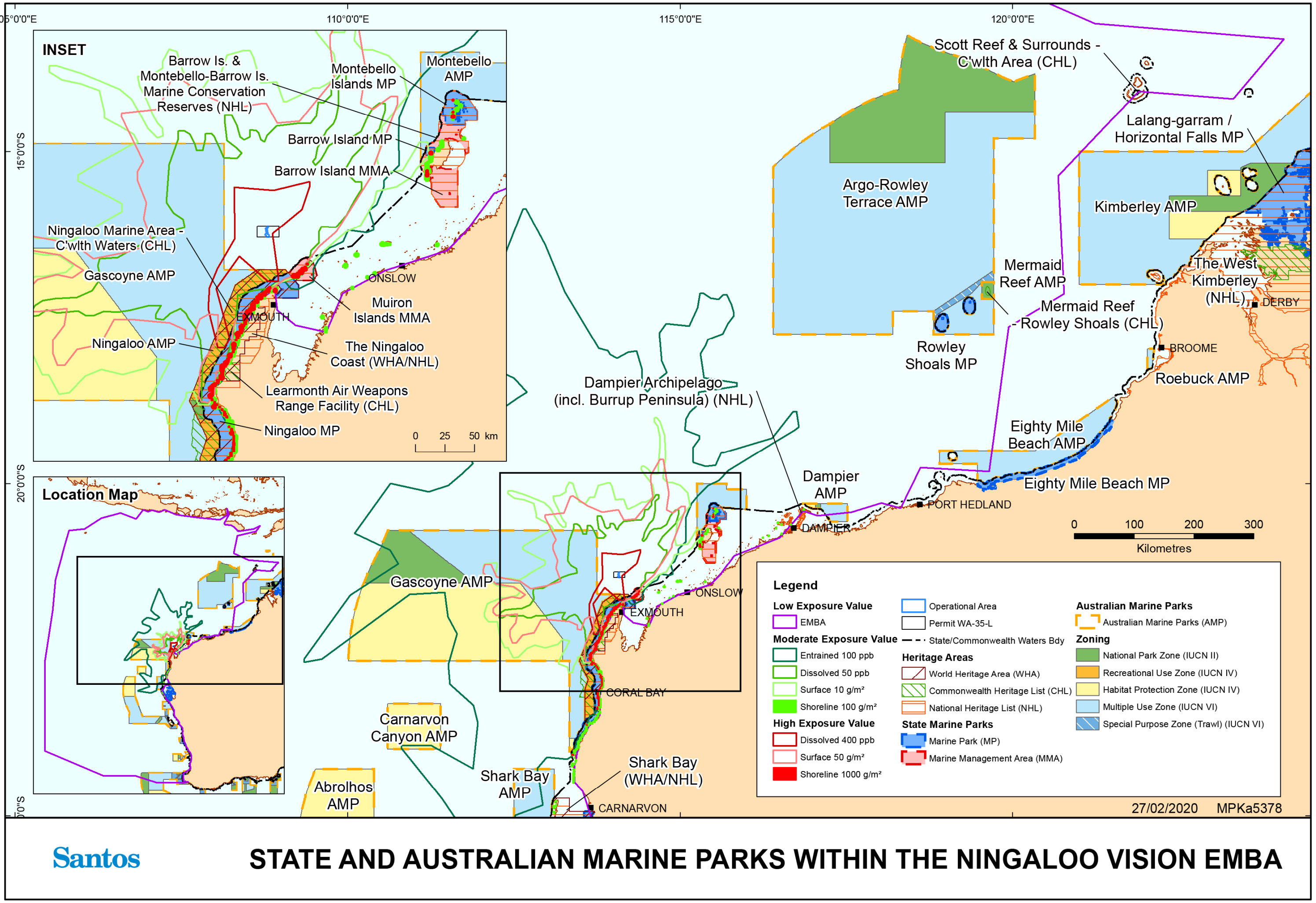


Figure 3-3A: State and Australian Marine Parks within the Ningaloo Vision EMBA

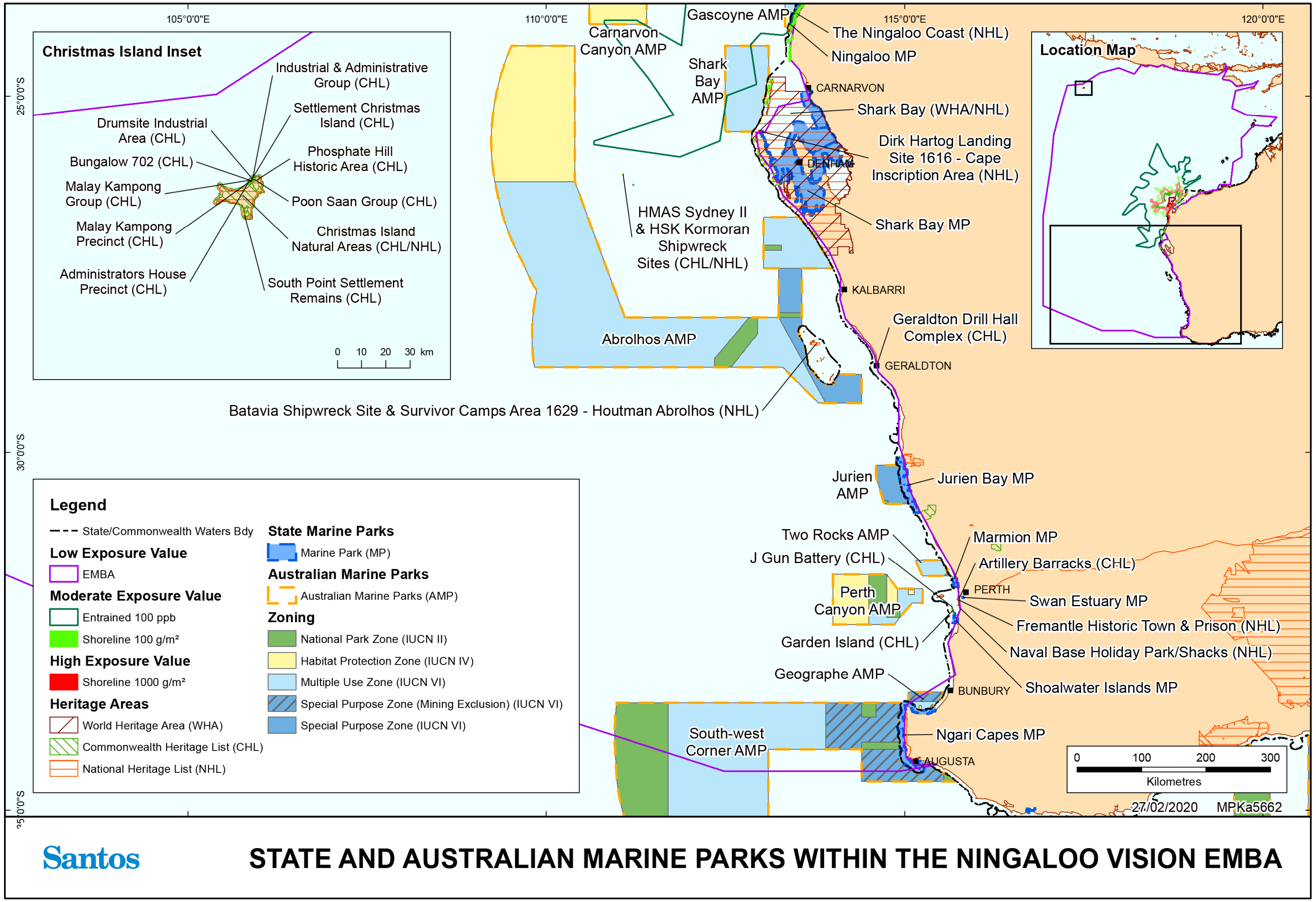


Figure 3 3B: State and Australian Marine Parks within the Ningaloo Vision EMBA

Table 3-3: Key Values and Sensitivities within the Operational Area and EMBA

Value/sensitivity		Name	IUCN Classification	Operational Area	Distance to Operational Area
World Heritage Areas		Ningaloo WHA	-	No	30 km
		Shark Bay WHA	-	No	350 km
Commonwealth heritage place		Commonwealth waters of the Ningaloo Marine Park	-	No	27 km
National Heritage Place		The Ningaloo Coast Heritage Area	-	No	30 km
		The Dampier Archipelago	-	No	260 km
Ramsar Wetlands		The Dales		No	1505 km
		Hosnies Spring		No	1498 km
		Peel-Yalgorup System		No	1243 km
National Heritage Properties	Natural	Shark Bay	-	No	350 km
		The Ningaloo Coast	-	No	35 km
	Indigenous	Dampier Archipelago (including Burrup Peninsula)	-	No	260 km
	Historic	Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos	-	No	784 km
		Dirk Hartog Landing Site 1616 – Cape Inscription Area	-	No	350 km
Australian Marine Park (AMP)		Ningaloo AMP	Recreational Use Zone (IUCN IV) National Park Zone (IUCN II)	No	27 km
		Gascoyne AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	No	28 km

Value/sensitivity	Name	IUCN Classification	Operational Area	Distance to Operational Area
	Montebello AMP	Multiple Use Zone (IUCN VI)	No	133 km
	Dampier AMP	Multiple Use Zone (IUCN VI)	No	307 km
	Shark Bay AMP	Multiple Use Zone (IUCN VI)	No	335 km
	Carnarvon Canyon AMP	Habitat Protection Zone (IUCN IV)	No	347 km
	Abrolhos AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI) Special Purpose Zone (IUCN VI)	No	370 km
	Argo-Rowley Terrace AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	No	465 km
	Eighty Mile Beach AMP	Multiple Use Zone (IUCN VI)	No	534 km
	Mermaid Reef	National Park Zone (IUCN II)	No	731 km
	Jurien AMP	National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	No	971 km
	Kimberley AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	No	1013 km

Value/sensitivity	Name	IUCN Classification	Operational Area	Distance to Operational Area
	Two Rocks AMP	Multiple Use Zone (IUCN VI)	No	1124 km
	Perth Canyon AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	No	1139 km
	Geographe AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI) Special Purpose Zone (Mining Exclusion) (IUCN VI)	No	1328 km
	South-West Corner AMP	Habitat Protection Zone (IUCN IV) National Park Zone (IUCN II) Multiple Use Zone (IUCN VI) Special Purpose Zone (Mining Exclusion) (IUCN VI)	No	1139 km
State Marine Reserves	Muiron Island Marine Management Area	Sanctuary Zone Special Purpose Zone Recreation Zone General Use Zone	No	32 km
	Ningaloo Marine Park	National Park Zone (IUCN II) Sanctuary Zone	No	30 km

Value/sensitivity	Name	IUCN Classification	Operational Area	Distance to Operational Area
		Special Purpose Zone Recreation Zone General Use Zone		
	Montebello/Barrow Islands Marine Conservation Reserve	Sanctuary Zone	No	132 km
	Shark Bay Marine Park	Multiple Use Zone (IUCN VI) Sanctuary Zone	No	392 km
	Ngari Capes Marine Park	Sanctuary zone Recreation Zone Special Purpose Zone General Use Zone	No	1,339 km
	Jurien Bay Marine Park	Sanctuary Zone Special Purpose Zone Aquaculture zone General Use Zone	No	962 km
	Barrow Island Marine Park	Sanctuary Zone	No	139 km
	Barrow Island Management Area	Conservation area Unzoned area	No	133 km
	Rowley Shoals Marine Park	Sanctuary Zone Recreation Zone General Use Zone	No	644 km
	Marmion Marine Park	Sanctuary Zone General Use Zone Watermans Reef	No	1,152 km

Value/sensitivity	Name	IUCN Classification	Operational Area	Distance to Operational Area
		Observation Area		
Key Ecological Features	Continental slope demersal fish communities	-	Yes	Overlaps
	Canyons linking the Argo Abyssal Plain with Scott Plateau	-	No	944km
	Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	-	No	6 km
	Ancient coastline at 125 m contour	-	No	23 km
	Commonwealth water adjacent to Ningaloo Reef	-	No	27 km
	Exmouth plateau	-	No	68 km
	Glomar Shoals	-	No	317 km
	Mermaid Reef and Commonwealth waters	-	No	365 km
	Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex	-	No	1,128 km
	Wallaby Saddle	-	No	508 km
	Ancient coastline at 90-120m depth	-	No	697 km
	Cape Mentelle upwelling	-	No	1,431 km
	Commonwealth marine environment surrounding the Houtman Abrolhos Island	-	No	738 km
	Commonwealth marine environment within and adjacent to Geographe bay	-	No	1,339 km
	Commonwealth marine environment	-	No	736 km

Santos

Value/sensitivity	Name	IUCN Classification	Operational Area	Distance to Operational Area
	within and adjacent to the west-coast inshore lagoons			
	Commonwealth Waters adjacent to Ningaloo Reef KEF	-	No	30 km
	Naturaliste Plateau	-	No	1,328 km
	Perth Canyon and adjacent shelf break, and other west-coast canyons	-	No	1,154 km
	Western demersal slope associated fish communities	-	No	490 km
	Western rock lobster	-	No	697 km

Table 3-4: Australian IUCN Reserve Management Principles (Schedule 8 of the EPBC Regulations 2000)

Applicable Marine Park	IUCN principles
National Park (IUCN II)	
Ningaloo AMP, Gascoyne AMP, Ningaloo Marine Park, Abrolhos AMP	The reserve or zone should be protected and managed to conserve its natural condition according to the following principles.
	Natural and scenic areas of national and international significance should be protected for spiritual, scientific, educational, recreational or tourist purposes.
	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.
	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.
	Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur.
	Respect should be maintained for the ecological, geomorphologic, sacred and aesthetic attributes for which the reserve or zone was assigned to this category.
	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.
	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.
Habitat/species Management Area (IUCN IV)	
Ningaloo AMP, Gascoyne AMP, Carnarvon Canyon AMP, Abrolhos AMP	The reserve or zone should be managed primarily, including (if necessary) through active intervention, to ensure the maintenance of habitats or to meet the requirements of collections or specific species based on the following principles.
	Habitat conditions necessary to protect significant species, groups or collections of species, biotic communities or physical features of the environment should be secured and maintained, if necessary, through specific human manipulation.
	Scientific research and environmental monitoring that contribute to reserve management should be facilitated as primary activities associated with sustainable resource management.
	The reserve or zone may be developed for public education and appreciation of the characteristics of habitats, species or collections and of the work of wildlife management.
	Management should seek to ensure that exploitation or occupation inconsistent with these principles does not occur.
	People with rights or interests in the reserve or zone should be entitled to benefits derived from activities in the reserve or zone that are consistent with these principles.
	If the reserve or zone is declared for the purpose of a botanic garden, it should also be managed for the increase of knowledge, appreciation and enjoyment of Australia's plant heritage by establishing, as an integrated resource, a collection of living and herbarium specimens of Australian and related plants for study, interpretation, conservation and display.
Managed Resource Protected Area (IUCN VI)	
Montebello AMP, Gascoyne AMP, Shark Bay AMP, Abrolhos AMP	The reserve or zone should be managed mainly for the ecologically 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.

Table 3-5: Management Zone for the Australian Marine Parks found within the EMBA and the Associated Objectives

Management Zones	Objective
Australian Marine Parks	
Multiple Use (IUCN VI)	To provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are authorised and

Management Zones	Objective
	consistent with park values. Mining operations are defined in the EPBC Act and include oil spill response.
Recreational Use (IUCN IV)	The objective is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while providing for recreational use.
Habitat Protection Zone (IUCN IV)	The objective is to provide for the conservation of ecosystems, habitats and native species in as natural a state as possible, while allowing activities that do not harm or cause destruction to seafloor habitats.
National Park Zone (IUCN II)	The objective is to protect natural biodiversity with its underlying ecological structure and supporting environmental processes, and to promote education and recreation.
Special Purpose Zone (IUCN VI)	The objective is to protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial.
State Marine Parks	
Sanctuary Zones	The primary purpose of sanctuary zones is for the protection and conservation of marine biodiversity. Sanctuary zones are 'no-take' areas managed solely for nature conservation and low impact recreation and tourism.
Special Purpose Zones	*Special purpose (benthic protection zone)*: This zone has the priority purpose of conservation of benthic habitat *Special purpose (shore-based activities)* zone: Special purpose zones in marine parks are managed for a priority purpose or use, such as a seasonal event (e.g. wildlife breeding, whale watching) or a commercial activity (e.g. pearling).
Recreation Zones	Recreation zones have the primary purpose of providing opportunities for recreational activities, including fishing, for visitors and for commercial tourism operators, where these activities are compatible with the maintenance of the values of the zone
General Use Zones	Conservation of natural values is still the priority of general use zones, but activities such as sustainable commercial and recreational fishing, aquaculture, pearling and petroleum exploration and production may be permitted provided they do not compromise the ecological values of the marine park.

Oil and gas operations and associated oil spill response may be conducted in a Multiple Use Zone (VI) subject to the class approval and prescriptions within the *North-West Marine Parks Network Management Plan* (MPNMP) (Director of National Parks, 2018). The 'Class Approval – Mining Operations and Green House Gas Activities' for the North-West MPNMP came into effect on 1 July 2018. Prescriptions/conditions of the North-West MPNMP and Class Approval for the North-West MPNMP that are considered relevant to the scope of this EP are provided in **Table 3-6**.

Table 3-6: Prescriptions/Conditions from the North-West MPNMP 2018, and associated Class Approval – Mining Operations and Green House Gas Activities relevant to the Activities in this EP

Prescription/ Condition Number	Prescription / Condition	Relevant Section of EP
North-west MPNMP (Director of National Parks, 2018 [a])		
4.2.9.8	Notwithstanding Section 4.2.9.1 (of the North-West MPNMP), actions required to respond to oil pollution incidents, including environmental monitoring and remediation, in connection with mining operations authorised under the OPGGS Act, may be conducted in all zones without an authorisation issued by the Director, provided that the actions are taken in accordance with: 1. an environment plan that has been accepted by NOPSEMA, 2. and the Director is notified in the event of oil pollution within a marine park, or where an oil spill response action must be taken within a marine park, so far as reasonably practicable, prior to response action being taken.	This EP **Section 4** (Stakeholder Consultation), **Section 8.10** (Reporting and Notifications) and NV Operations OPEP (TV-00-RI-00003.02)
Class Approval – Mining Operations and Green House Gas Activities – for North-west MPNMP (Director of National Parks, 2018[a])		
1	Approved action must be conducted in accordance with: An environment plan accepted under the Offshore Petroleum and Greenhouse Gas Storage (environment) Regulations (2009)	OPEP (some proposed response activities in the event of an oil pollution incident may be undertaken within the North-West Marine Park Network).
	The EPBC Act 1999	**Appendix B**
	The EPBC Regulations 2000	This EP
	The North Network Management Plan	This table
	Any prohibitions, restrictions or determinations made under the EPBC Regulations by the Director of National Parks	Not applicable
	all other applicable Commonwealth and state and territory laws (to the extent those laws are capable of operating concurrently with the laws and instruments described in paragraphs A to E)	**Appendix B** (Legislation), and NV Operations OPEP (TV-00-RI-00003.02)

Prescription/ Condition Number	Prescription / Condition	Relevant Section of EP
2	If requested by the Director of National Parks, an Approved Person must notify the Director prior to conducting Approved Actions within Approved Zones Note: the timeframe for prior notice will be agreed to by the Director of National Parks and the Approved person	**Section 8.11** (Reporting and Notifications) and the OPEP.
3	If requested by the Director of National Parks, an Approved person must provide the Director with information relating to undertaking the Approved Actions or gathered while undertaking the Approved Actions) that is relevant to the Director's management of the Approved Zones. Note: the information required and timeframe within which it is required will be agreed to by the Director of National Parks and the Approved Person	Not applicable

3.2.4 Marine Fauna

3.2.4.1 Threatened and Migratory Species

Table 3-7 presents the environmental values and sensitivities (threatened and migratory species) within the operational area, PW mixing zone and EMBA. These include all relevant Matters of National Environmental Significance (MNES) protected under the EPBC Act 1999 as identified in the PMST search for the operational area and EMBA (**Appendix D2** and **D3**), note that the PW mixing zone is within the operational area. For each species identified, the extent of likely presence is provided, including any overlap with designated Biologically Important areas (BIAs). BIAs such as an aggregation, breeding, resting, nesting or feeding areas or known migratory routes for these species are shown in **Figure 3-4** to **Figure 3-12** and described in the EE (**Appendix D1)**.

The PMST search identified 36 marine fauna species listed as `threatened' species and 30 marine fauna species listed as `migratory' within the operational area and within the PW mixing zone. In the wider EMBA there were 116 total marine fauna identified. 97 species were identified as "Migratory". 36 were identified as threatened and 56 were identified as threatened. species. Other listed marine species that may occur within the operational area and EMBA are provided in the EE (**Appendix D1**). Note that terrestrial species (such as terrestrial mammals, reptiles and bird species) that appear in the EPBC search of the EMBA and do not have habitats along shorelines are not relevant to the NV operations impacts and risks have been excluded from **Table 3-7.**

The following BIAs also occur within the EMBA; however are not listed in **Table 3-7** as they were not returned in the PMST search results:

+ Fairy tern (Breeding and Foraging (in high numbers));
+ Lesser crested tern (Breeding);
+ Little shearwater (Foraging (in high numbers));
+ Pygmy blue whale (Distribution, Foraging and Migration);
+ Pacific gull (Foraging (in high numbers));
+ Sooty tern (Foraging);
+ White-faced storm petrel (Foraging (in high numbers);

+ Indian yellow-nosed albatross (breeding);
+ Little penguin (Breeding);
+ Red footed booby (Foraging);
+ Soft-plumaged petrel (foraging); and
+ White-tailed tropicbird (breeding).

Table 3-7: Protected Species and Communities within the Operational Area, PW mixing zone and EMBA

Value/Sensitivity		EPBC Act Status	Operational Area Presence	Particular Values or Sensitivities within Operational Area	PW mixing zone presence	Particular Values or Sensitivities within PW mixing zone	EMBA Presence	Particular Values or Sensitivities within EMBA	Relevant Events
Common Name	**Scientific Name**	CE = Critically Endangered E = Endangered V = Vulnerable M = Migratory CD = Conservation Dependent							
Protected Species and Communities: Fish and Sharks									
Whale shark	*Rhincodon typus*	**V, M**	**X**	N/A	**X**	N/A	✓	Foraging, feeding or related behaviour known to occur within area. Overlap with foraging and aggregation BIA	Planned + Noise emissions (Section 6.1) + Light emissions (Section 6.2) + Planned operational discharges (Section 6.5) + Discharge of PW (Section 6.7 + Spill response operations (Section 6.8) Unplanned + Introduction of IMS (Section 7.1) + Interaction with Marine Fauna (Section 7.2) + Discharge of solid object (Section 7.3) + Hazardous material (solid and liquid) releases (Section 7.4) + Hydrocarbon releases (Section 7.6 to 7.11)
Northern River Shark, New Guinea River Shark	*Glyphis garricki*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Freshwater Sawfish	*Pristis*	**V,M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Grey nurse shark (west coast population)	*Carcharias taurus (west coast population)*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
White shark	*Carcharodon carcharias*	**V, M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Foraging, feeding or related behaviour known to occur within area, Overlap with BIA for foraging	
Dwarf sawfish	*Pristis clavata*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Green sawfish	*Pristis zijsron*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Narrow sawfish	*Anoxypristis cuspidata*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat likely to occur within area	
Shortfin mako	*Isurus oxyrinchus*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	
Longfin mako	*Isurus paucus*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	
Porbeagle, mackerel shark	*Lamna nasus*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Reef manta ray	*Manta alfredi*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Giant manta ray	*Manta birostris*	**M**	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	✓	Species or species habitat known to occur within area	
Blind Gudgeon	*Milyeringa veritas*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	

Balston's Pygmy Perch	*Nannatherina balstoni*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Blind Cave Eel	*Ophisternon candidum*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Protected Species and Communities: Marine Mammals									
Humpback whale	*Megaptera novaeangliae*	**V, M**	✓	Species or species habitat known to occur within area Overlap with BIA for migration	✓	Species or species habitat known to occur within area Overlap with BIA for migration	✓	Congregation or aggregation known to occur within area Overlap with BIA for migration (north and south) and resting	<u>Planned</u> + Noise emissions (Section 6.1) + Light emissions (Section 6.2) + Planned operational discharges (Section 6.5) + Discharge of PW (Section 6.7 + Spill response operations (Section 6.8) <u>Unplanned</u> + Introduction of IMS (Section 7.1) + Interaction with Marine Fauna (Section 7.2) + Discharge of solid object (Section 7.3) + Hazardous material (solid and liquid) releases (Section 7.4) + Hydrocarbon releases (Section 7.6 to 7.11)
Blue whale	*Balaenoptera musculus*	**E, M**	✓	Migration route known to occur within area	✓	Migration route known to occur within area	✓	Migration route known to occur within area, Overlap with BIA for foraging (on migration)	
Sei whale	*Balaenoptera borealis*	**V, M**	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	✓	Foraging, feeding or related behaviour likely to occur within area	
Fin whale	*Balaenoptera physalusk*	**V, M**	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	✓	Foraging, feeding or related behaviour likely to occur within area	
Bryde's whale	*Balaenoptera edeni*	**M**	✓	Species or species habitat likely occur within area	✓	Species or species habitat likely occur within area	✓	Species or species habitat likely to occur within area	
Orca, killer whale	*Orcinus orca*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	
Spotted bottlenose dolphin	*Tursiops aduncus (Arafura/Timor Sea Populations)*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area	
Sperm whale	*Physeter macrocephalus*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area, Overlap with BIA for foraging (abundant food source)	
Indo-Pacific humpback dolphin	*Sousa chinensis*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Dugong	*Dugong dugon*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap with BIA for breeding, foraging (high density seagrass beds), nursing and calving	
Southern right whale	*Eubalaena australia*	**E, M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat likely to occur within area, Overlap with BIA for seasonal calving habitat	

Australian Sea-lion	*Neophoca cinerea*	**V**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area, Overlap with BIA for foraging	
Antarctic minke whale	*Balaenoptera bonaerensis*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area	
Pygmy right whale	*Caperea marginata*	**M**	**X**	N/A	**X**	NA	✓	Foraging, feeding or related behaviour known to occur in area	
Dusky dolphin	*Lagenorhhynchus Obscurus*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area	
Australian snubfin dolphin	*Orcaella heinsohni*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area	
Protected Species and Communities: Marine Reptiles									
Short-nosed seasnake	*Aipysurus apraefrontalis*	**CE**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	Planned + Noise emissions (Section 6.1) + Light emissions (Section 6.2) + Planned operational discharges (Section 6.5) + Discharge of PW (Section 6.7) + Spill response operations (Section 6.8) Unplanned + Introduction of IMS (Section 7.1) + Interaction with Marine Fauna (Section 7.2) + Discharge of solid object (Section 7.3) + Hazardous material (solid and liquid) releases (Section 7.4) + Hydrocarbon releases (Section 7.6 to 7.11)
Olive Ridley turtle, pacific Ridley turtle	*Lepidochelys olivacea*	**E, M**	**X**	N/A	**X**	N/A	✓	Foraging, feeding or related behaviour known to occur	
Loggerhead turtle	*Caretta caretta*	**E, M**	✓	Species or species habitat known to occur within area	✓	Species or species habitat known to occur within area	✓	Breeding known to occur within area Overlap interesting and nesting BIA	
Green turtle	*Chelonia mydas*	**V, M**	✓	Species or species habitat known to occur within area	✓	Species or species habitat known to occur within area	✓	Breeding known to occur within area Overlap interesting, foraging, mating, nesting and aggregation BIA	
Leatherback turtle	*Dermochelys coriacea*	**E, M**	✓	Species or species habitat known to occur within area	✓	Species or species habitat known to occur within area	✓	Foraging, feeding or related behaviour known to occur within area Breeding likely to occur within area	
Hawksbill turtle	*Eretmochelys imbricata*	**V, M**	✓	Species or species habitat known to occur within area	✓	Species or species habitat known to occur within area	✓	Breeding known to occur within area Overlap with interesting, mating, nesting, foraging and nesting BIA	
Flatback turtle	*Natator depressus*	**V, M**	✓	Congregation or aggregation known to occur within area	✓	Congregation or aggregation known to occur within area	✓	Breeding known to occur within area Overlap with interesting, nesting and foraging BIA	
Protected Species and Communities: Marine Birds									
Curlew sandpiper	*Calidris ferruginea*	**CE, M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area	Planned + Noise emissions (Section 6.1) + Light emissions (Section 6.2) + Noise emissions (Section 6.1 + Planned operational discharges (Section 6.5)
Australasian bittern	*Botaurus poiciloptilus*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Lesser sand lover, Mongolian Plover	*Charadrius mongolus*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat may to occur within area	

Christmas island frigatebird, Andrew's frigatebird	*Fregata andrewsi*	**E, M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area	+ Discharge of PW (Section 6.7 + Spill response operations (Section 6.8) Unplanned + Introduction of IMS (Section 7.1) + Interaction with Marine Fauna (Section 7.2) + Discharge of solid object (Section 7.3) + Hazardous material (solid and liquid) releases (Section 7.4) + Hydrocarbon releases (Section 7.6 to 7.11)
Blue petrel	*Halobaena caerula*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat may to occur within area	
Fairy prion (southern)	*Pachyptila turtur subantarctica*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat may to occur within area	
Christmas Island white-tailed tropicbird, Golden bosunbird	*Paethon leturus fulvus*	**E**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area	
Sooty albatross	*Phoebetria fusca*	**E**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area	
White-tailed tropicbird	*Phaethon lepturus*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area	
Little tern	*Sternula albifrons*	**M**	**X**	N/A	**X**	N/A	✓	Congregation or aggregation known to occur within area, Overlap with resting BIA	
Masked booby	*Sula dactylatra*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area	
Brown booby	*Sula leucogaster*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area, Overlap with foraging (on migration BIA)	
Red-footed Booby	*Sula*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap with Foraging and Breeding BIA	
Common sandpiper	*Actitis hypoleucos*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Ruddy turnstone	*Arenaria interpres*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Red-necked stint	*Calidris ruficollis*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Long-toed stint	*Calidris subminuta*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Broad-billed sandpiper	*Limicola falcinellus*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Black-tailed godwit	*Limosa Limosa*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Little curlew	*Numenius minutus*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Red-necked	*Pharalope lobatus*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Ruff (Reeve)	*Pjilomachus pugnax*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Pacific golden plover	*Pluvialis fulva*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Grey-tailed tattler	*Tringa brevipes*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Wood sandpiper	*Tringa glareola*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Marsh sandpiper	*Tringa stagnatilis*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	
Common redshank	*Tringa totanus*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area	

Terek sandpiper	*Xenus cinereus*	**M**	**X**	N/A	**X**	N/A	✓	Roosting known to occur within area
Red knot	*Calidris canutus*	**E, M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area
Southern giant petrel	*Macronectes giganteus*	**E, M**	✓	Species or species habitat may to occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area, Overlap with BIA for foraging
Northern giant petrel	*Macronectes giganteus*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may to occur within area
Abbott's booby	*Papasula abbotti*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat may to occur within area
Eastern curlew	*Numenius madagascariensis*	**CE, M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area
Common noddy	*Anous stolidus*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat likely to occur within area Overlap foraging (provisioning young) BIA
Great knot	*Calidris tenuirostris*	**CE, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Australian painted snipe	*Rostratula australis*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area
Australian lesser noddy	*Anous tenuirostris melanops*	**V**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap Foraging (provisioning young) BIA
Streaked shearwater	*Calonectris leucomelas*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area
Lesser frigatebird	*Fregata ariel*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area, Overlap breeding BIA
Common sandpiper	*Actitis hypoleucos*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area
Sanderling	*Calidris alba*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Sharp-tailed sandpiper	*Calidris acuminata*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area
Pectoral sandpiper	*Calidris melanotos*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area
Osprey	*Pandion haliaetus*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Breeding known to occur within area

Bar-tailed godwit	*Limosa lapponica baueri*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area
Northern Siberian bar-tailed godwit	*Limosa lapponica menzbierii*	**CE, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area
Australian fairy tern	*Sternula nereis*	**V**	✓	Foraging, feeding or related behaviour likely to occur within area	✓	Foraging, feeding or related behaviour likely to occur within area	✓	Breeding known to occur within area, Overlap foraging and breeding BIA
Greater sand plover	*Charadrius leschenaultia*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Fork-tailed swift	*Apus pacificus*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area
Whimbrel	*Numenius phaeopus*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Wedge-tailed shearwater	*Ardenna pacifca*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap breeding and foraging BIA
Greater frigatebird	*Fregata minor*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area Overlap breeding and foraging BIA
Caspian tern	*Hydroprogne caspia*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap foraging (provisioning young) BIA
Bridled tern	*Onychoprion anaethetus*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap foraging (in high numbers) BIA
Roseate tern	*Stern dougallii*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area Overlap with BIA for foraging and breeding
Crested tern	*Thalasseus bergii*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area
Grey-tailed Tattler	*Tringa brevipes*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Wood sandpiper	*Tringa glareola*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Terek sandpiper	*Xenus cinereus*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area
Red-tailed tropicbird	*Phaethon rubricauda*	**M**	**X**	N/A	**X**	N/A	✓	Breeding known to occur within area
Oriental plover	*Charadrius plover*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area

Pacific Golden Plover	*Pluvialis fulva*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Grey Plover	*Pluvialis squatarola*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
Oriental pratincole	*Glareola maldivarum*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Common greenshank	*Tringa nebularia*	**M**	**X**	N/A	**X**	N/A	✓	Species or species habitat known to occur within area	
White-winged Fairy wren (Barrow Island), Barrow Island Black-and-white Fairy-wren	*Malurus leucopterus edouardi*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area	
White-winged Fairy wren (Dirk Hartog Island), Dirk Hartog black-and-white fairy-wren	*Malurus leucopterus leucopterus*	**V**	**X**	N/A	**X**	N/A	✓	Species or species habitat likely to occur within area	
Soft-plumaged petrel	*Pterodroma mollis*	**V**	**X**	N/A	**X**	N/A	✓	Foraging, feeding or related behaviour likely to occur within area, Overlap foraging (in high numbers) BIA	
Indian yellow-nosed albatross	*Thalassarche carteri*	**V, M**	**X**	N/A	**X**	N/A	✓	Foraging, feeding or related behaviour may occur within area, Overlap foraging (in high numbers) BIA	
Shy albatross	*Thalassarche cauta*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
White-capped albatross	*Thalassarche cauta steadi*	**V, M**	**X**	N/A	**X**	N/A	✓	Foraging, feeding or related behaviour likely to occur within area	
Campbell albatross	*Thalassarache impavida*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Black-browed albatross	*Thalassarche impavida*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Amsterdam albatross	*Diomedea amsterdamensis*	**E, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Southern royal albatross	*Diomedea epomophora*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Wandering albatross	*Diomedea exulans*	**V, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Northern royal albatross	*Diomedea sanfordi*	**E, M**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	
Tristan albatross	*Diomedea dabbenena*	**E**	**X**	N/A	**X**	N/A	✓	Species or species habitat may occur within area	

Flesh-footed shearwater	*Ardenna carneipes*	**M**	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	✓	Foraging, feeding or related behaviour likely to occur within area Overlap BIA Foraging and aggregation	

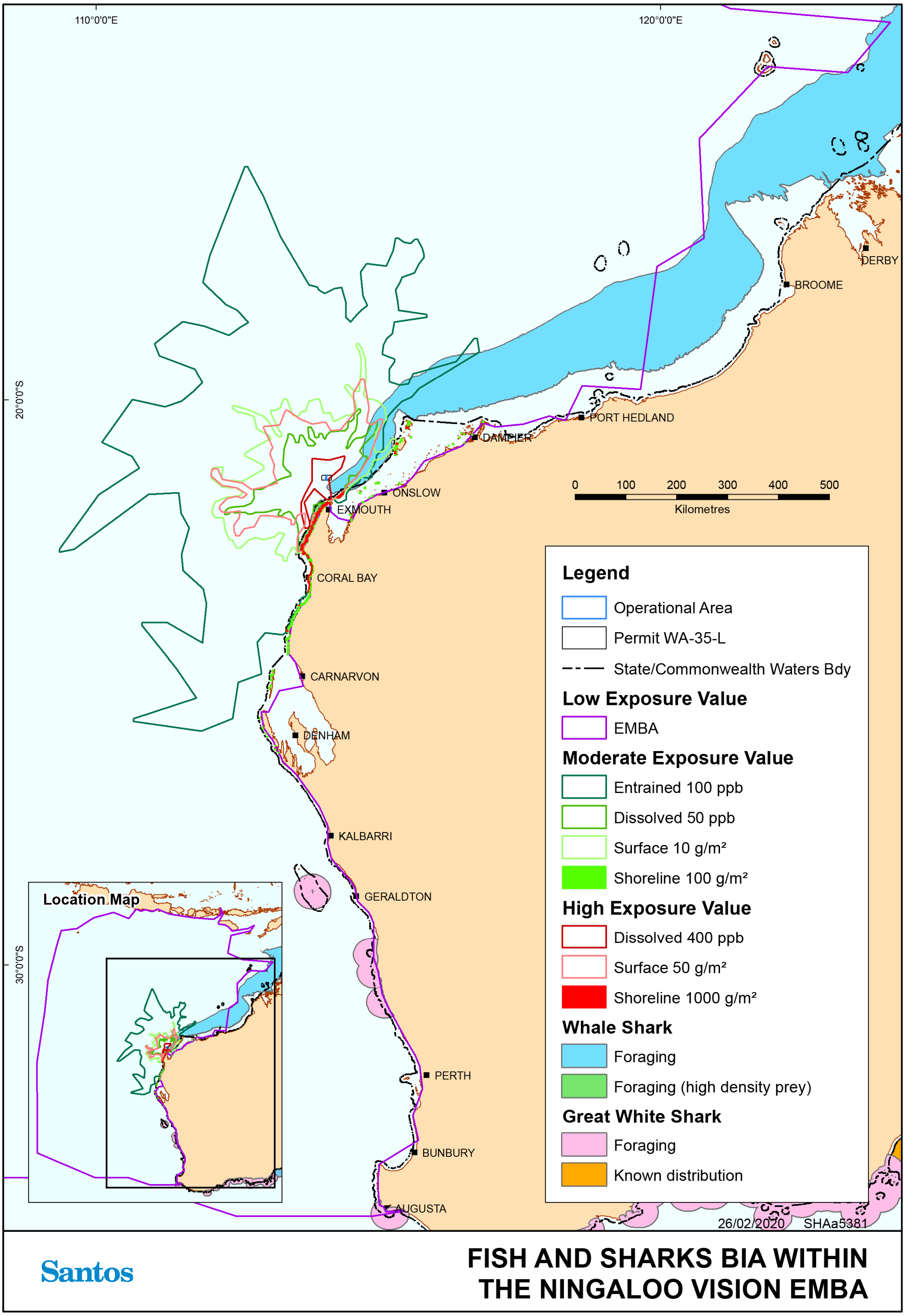


Figure 3-4: Fish and Sharks BIA within the EMBA

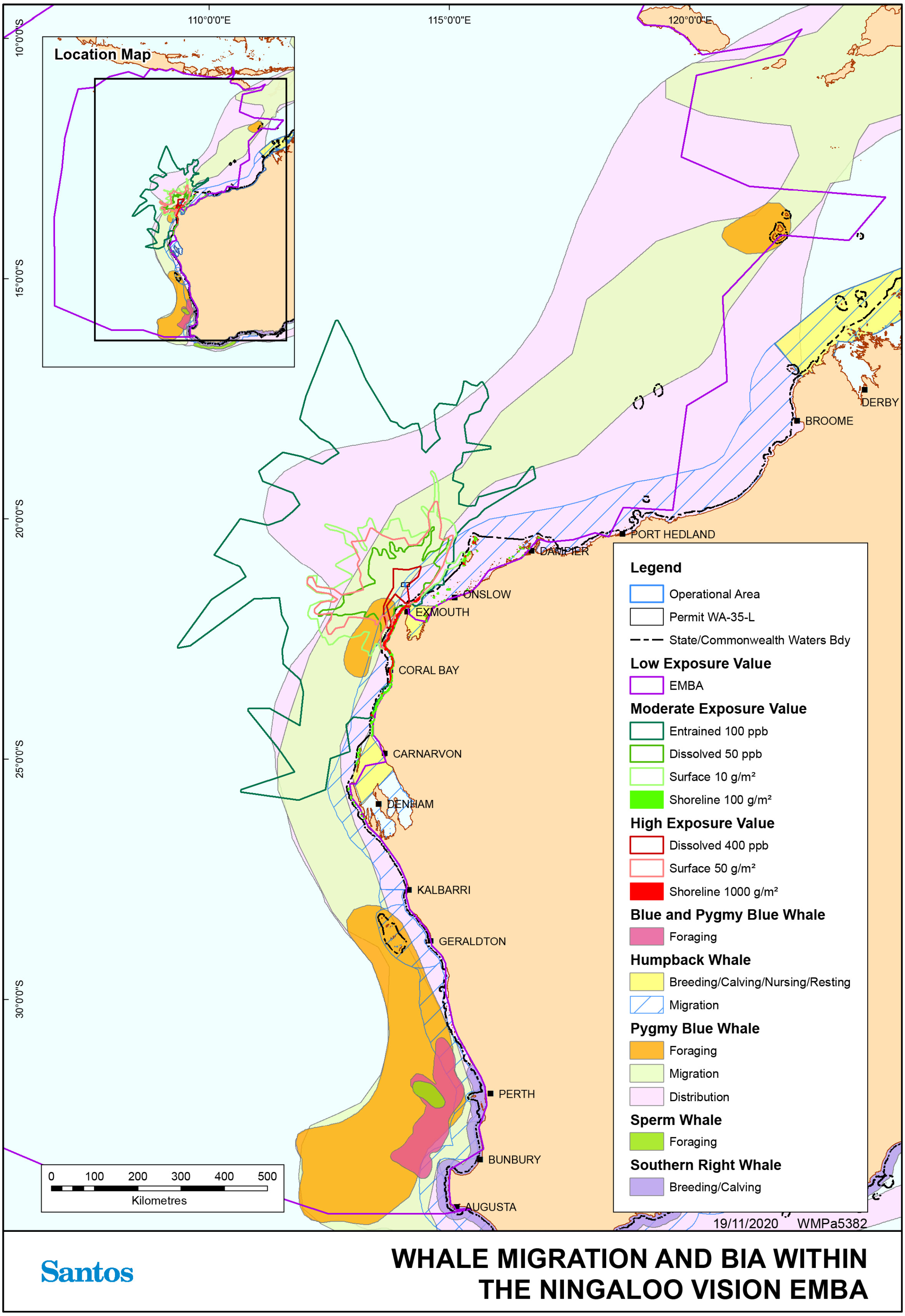


Figure 3-5: Whale Migration and BIA within the EMBA

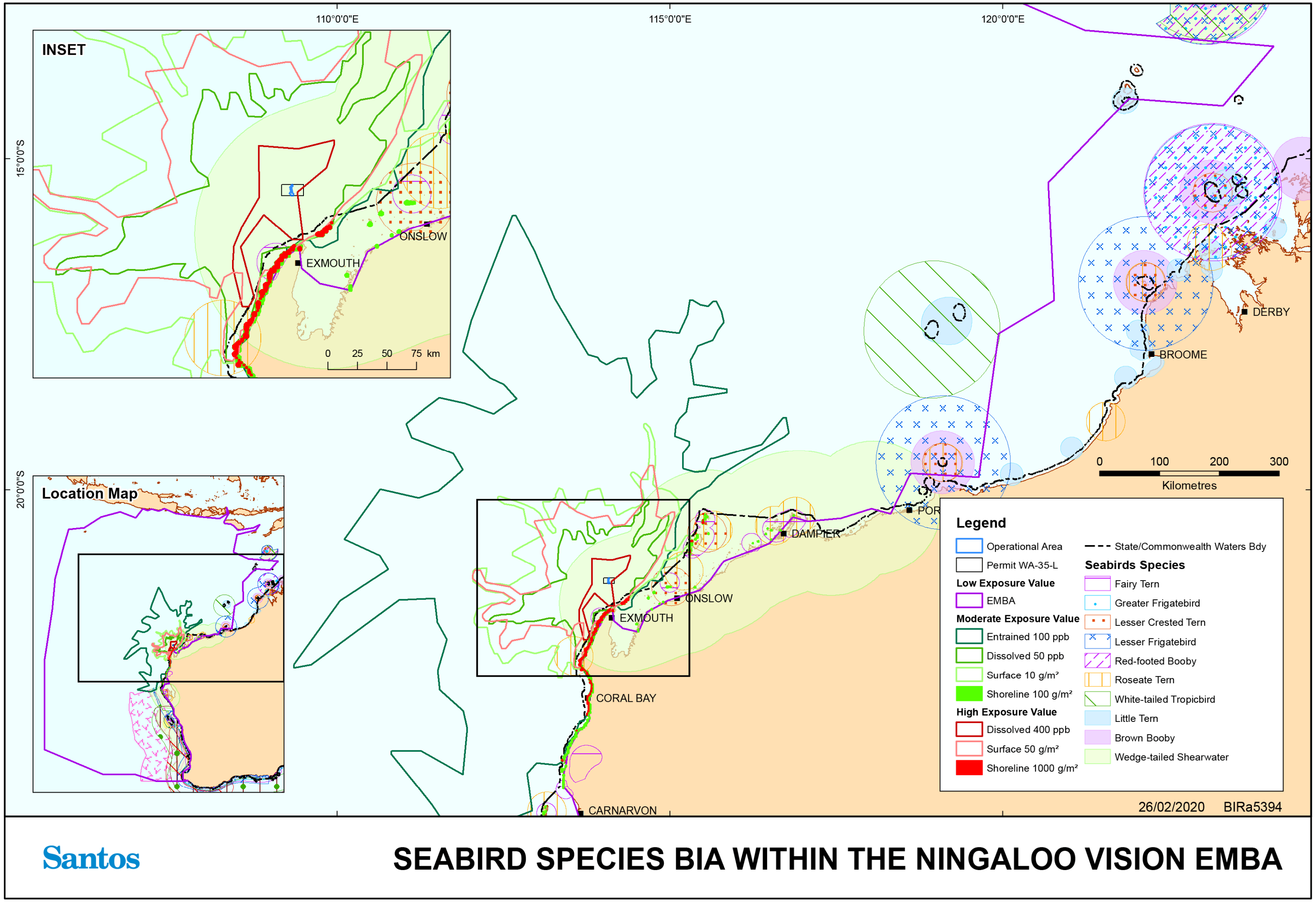


Figure 3-6A: Seabird Species BIAs within the EMBA

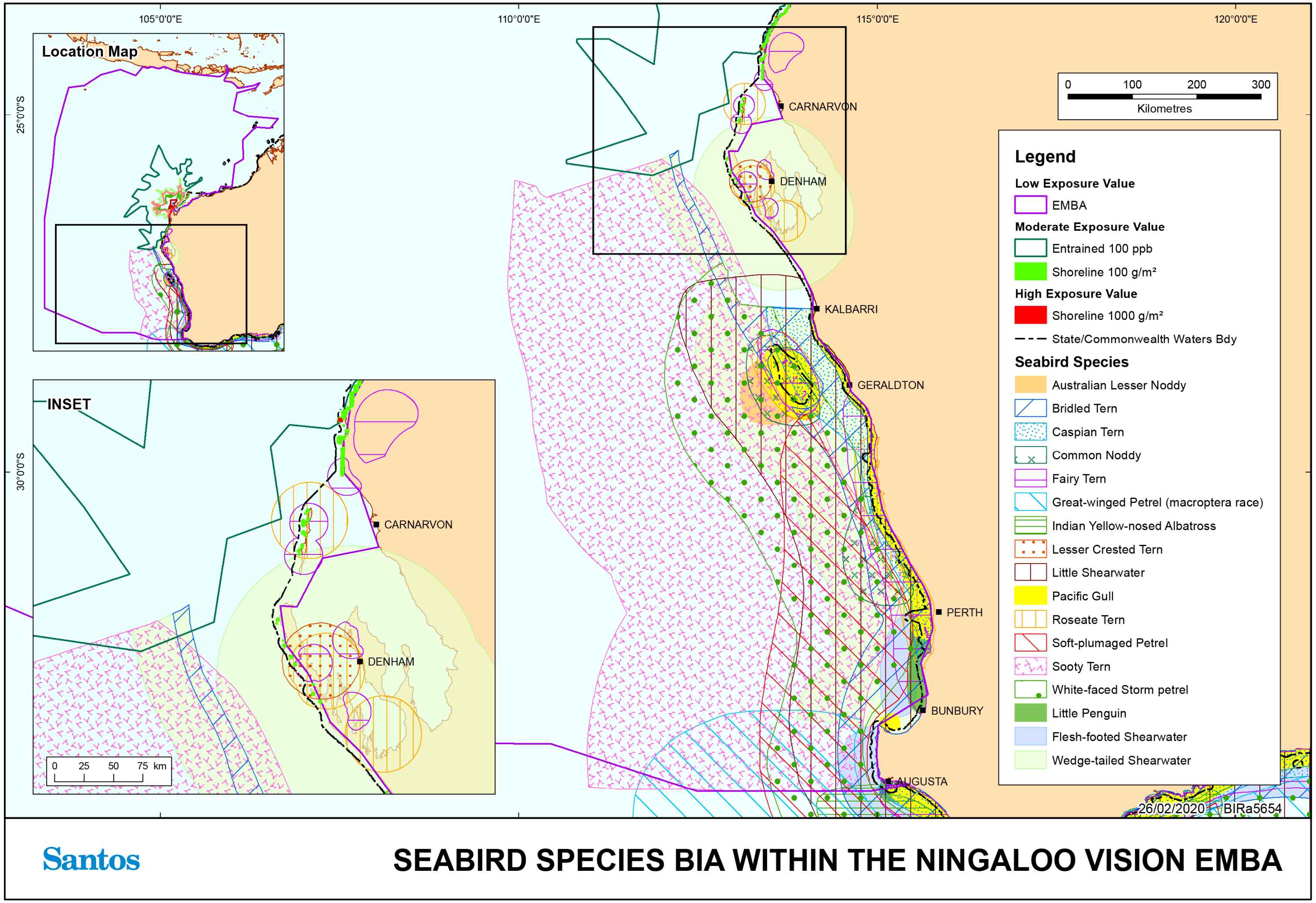


Figure 3 6B: Seabird Species BIAs within the EMBA

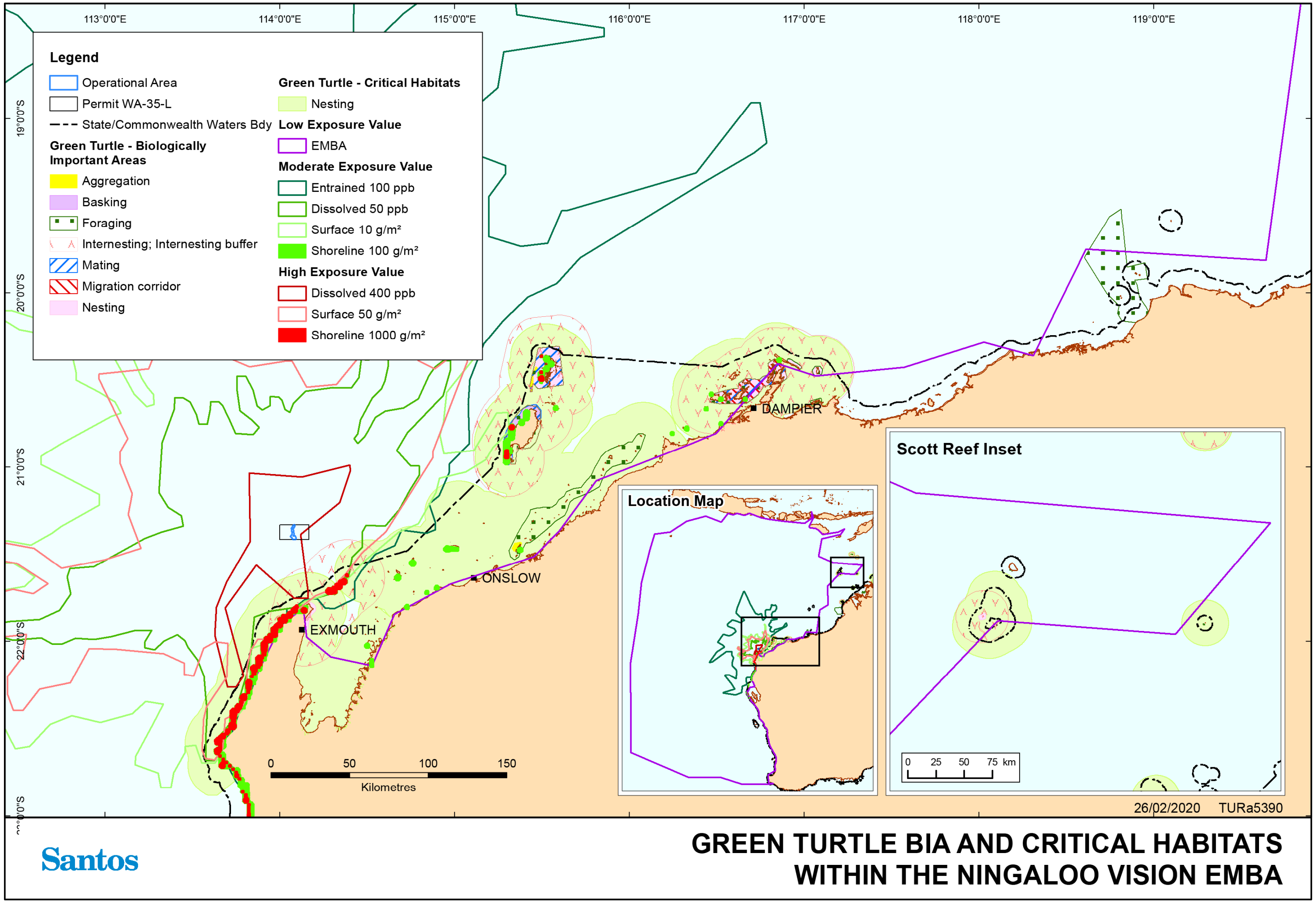


Figure 3-7: Green Turtle BIA and Critical Habitat within the EMBA

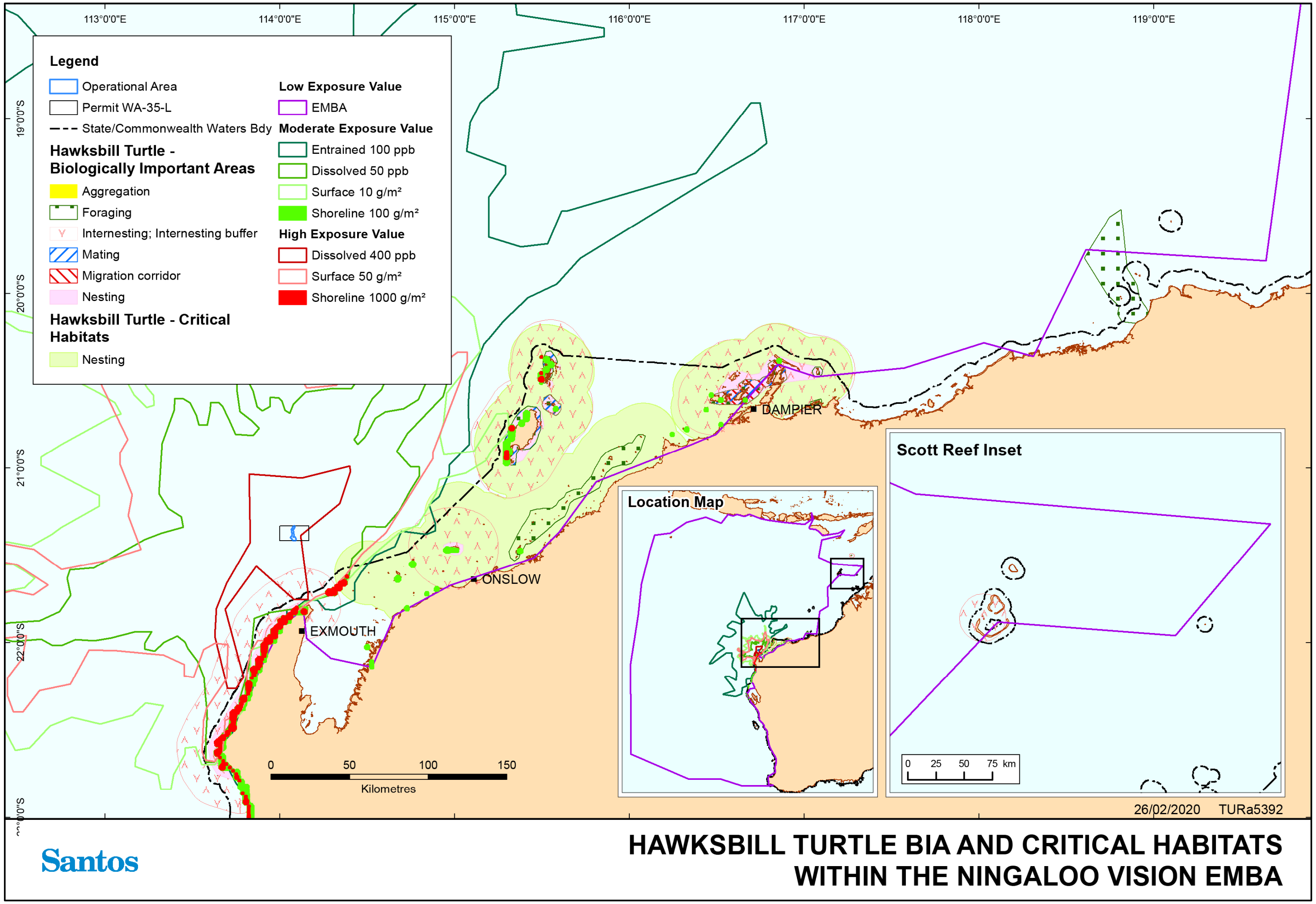


Figure 3-8: Hawksbill Turtles BIA and Critical Habitat within the EMBA

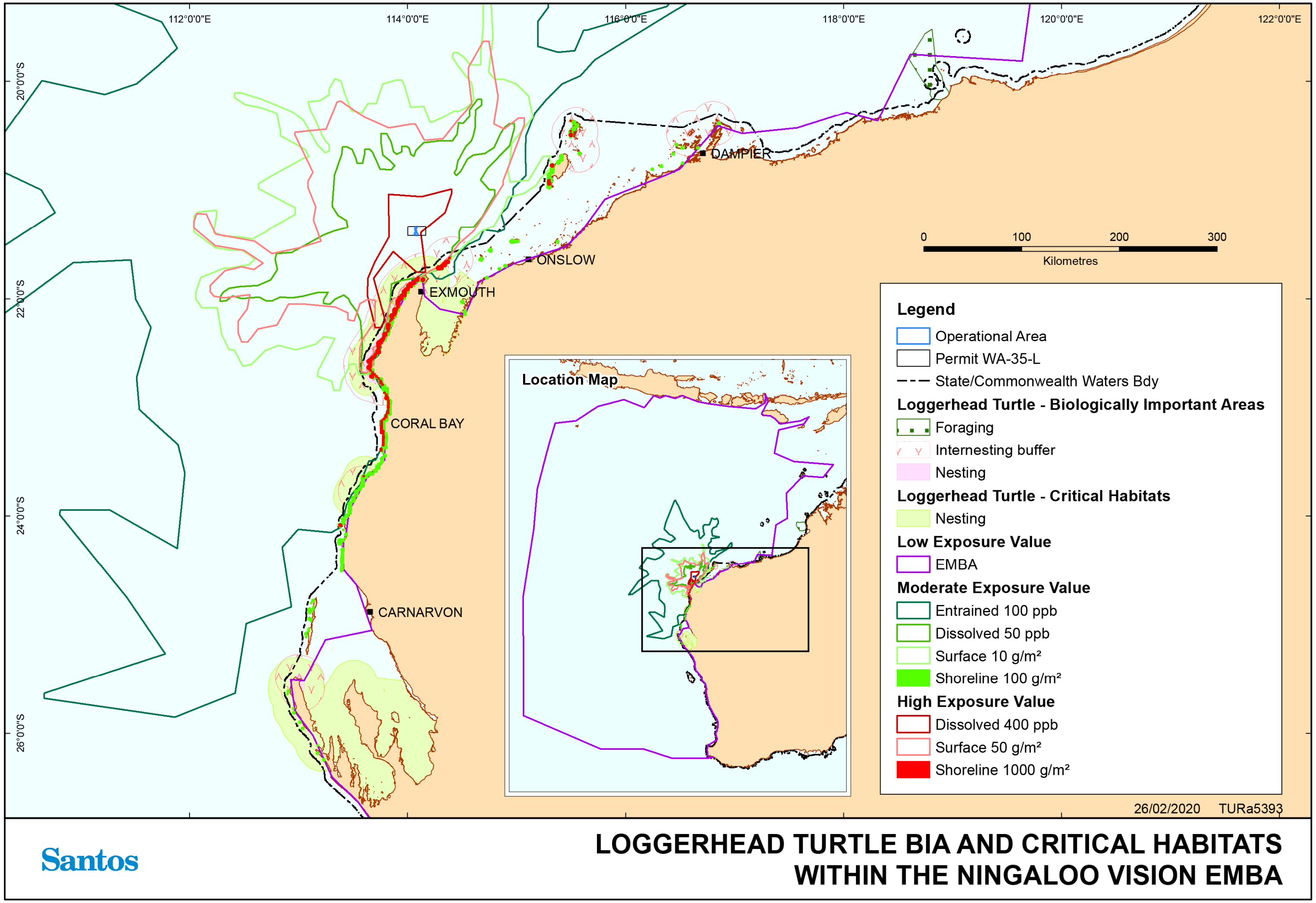


Figure 3-9: Loggerhead Turtle BIAs and Critical Habitat within the EMBA

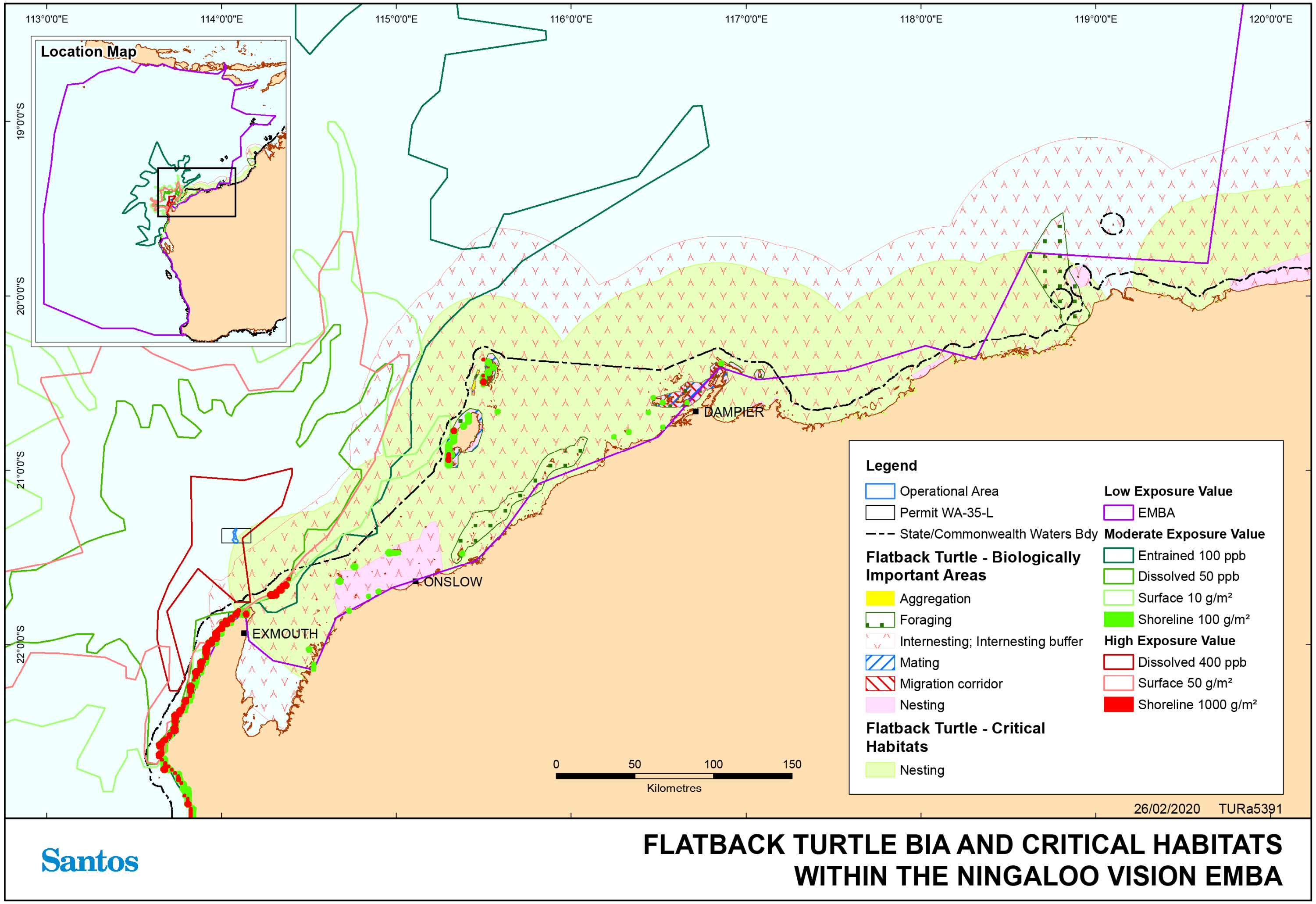


Figure 3-10: Flatback Turtle BIAs within the EMBA

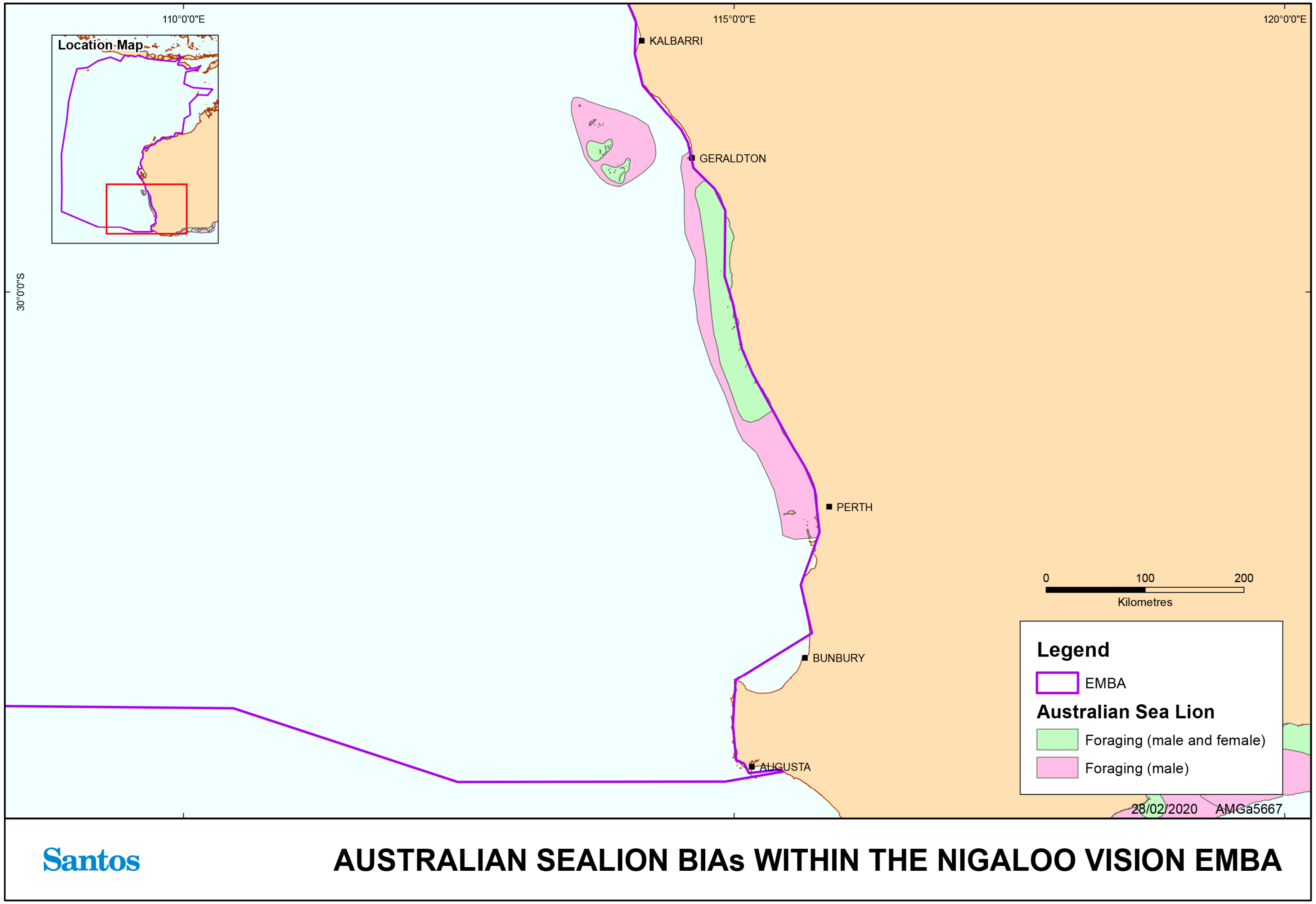
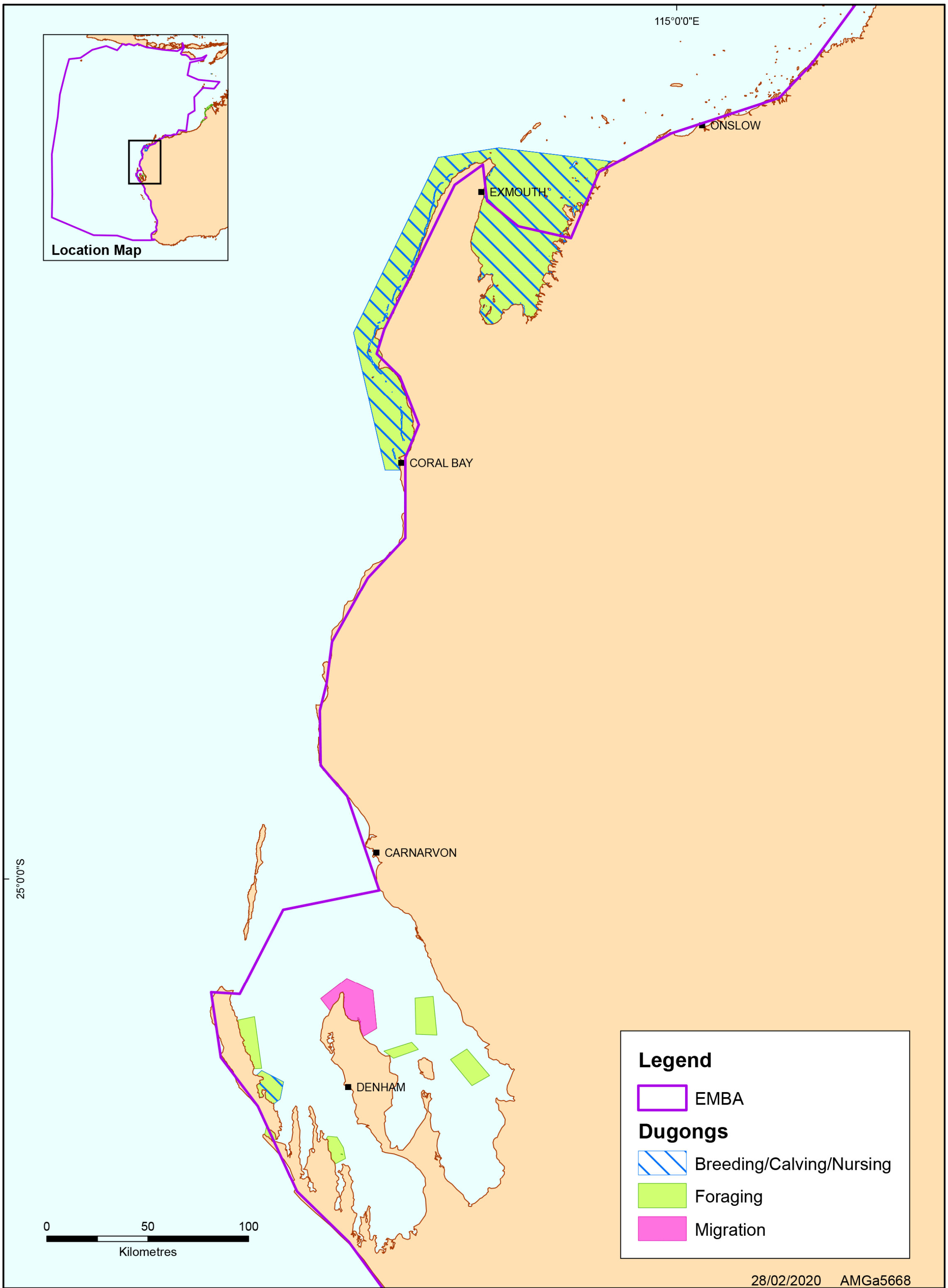


Figure 3-11: Australian Sealion BIAs within the EMBA



Santos **DUGONG BIAS WITHIN THE NIGALOO VISION EMBA**

Figure 3-12: Dugong BIAs within the EMBA

3.2.4.2 Recovery Plans

Recovery Plans set out the research and management actions necessary to stop the decline of and support the recovery of listed threatened species.

Table 3-8 summarises the actions relevant to the activity with more information on the specific requirements of the relevant plans of management (including Conservation Advice and Conservation Management Plans) applicable to the NV Operations, and demonstrates how current management requirements have been taken into account.

Table 3-8: Threats and strategies from Recovery Plans, Conservation Advice and Management Plans relevant to the activity

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
Cetaceans			
Blue whale	Conservation Management Plan for the Blue Whale 2015-2025 (2015) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Noise interference	**Section 6.1**
		Habitat modification	**Section 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
Australian Sea-Lion	Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*) (2013)	Noise interference	**Section 6.1**
		Habitat modification	**Section 7.3 7.4 7.6 – 7.10**
		Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
Fin whale	Approved Conservation Advice for *Balaenoptera physalus* (fin whale) (2015) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Anthropogenic noise and acoustic disturbance	**Section 6.1**
		Pollution (persistent toxic pollutants)	**Section 6.7 7.3 7.4, 7.6 7.7 – 7.10**
		Vessel strike	**Section 7.2**
Sei whale	Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Anthropogenic noise and acoustic disturbance	**Section 6.1**
		Habitat degradation including pollution (persistent toxic pollutants)	**Section 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Vessel strike	**Section 7.2**
Humpback whale		Noise interference	**Section 6.1**
		Marine debris	**Section 7.3 7.4**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (2015). Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Vessel strike	**Section 7.2**
Southern Right Whale	Conservation Management Plan for the Southern Right Whale 2011 – 2021 (2012)	Habitat modification	**Section 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
		Noise interference	**Section 6.1**
Marine Reptiles			
Short-nosed seasnake	Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011)	Degradation of reef habitat	**Section 7.6 – 7.10**
Loggerhead turtle	Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Noise interference	**Section 6.1**
		Marine debris	**Section 7.3 7.4**
		Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
		Loss of habitat and/or habitat modification	**Section 7.3 7.4 7.6 – 7.10**
		Light pollution	**Section 6.2**
Green turtle		Noise interference	**Section 6.1**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
	Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Vessel disturbance	**Section 7.2**
		Light pollution	**Section 6.2**
Leatherback turtle, leathery turtle	Commonwealth Conservation Advice on *Dermochelys coriacea* (2008) Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Boat strike	**Section 7.2**
		Changes to breeding sites	**Section 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Noise interference	**Section 6.1**
		Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Loss of habitat	**Section 6.4 7.3 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
		Light pollution	**Section 6.2**
Hawksbill turtle	Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Noise interference	**Section 6.1**
		Chemical and terrestrial discharge	**Section 6.6 6.4 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Loss of habitat	**Section 7.3 7.4 7.6 – 7.10**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
		Vessel disturbance	**Section 7.2**
		Light pollution	**Section 6.2**
Flatback turtle	Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Noise interference	**Section 6.1**
		Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Loss of habitat	**Section 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
		Light pollution	**Section 6.2**
Olive ridley turtle	Recovery plan for marine turtles in Australia 2017-2027 (2017) Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Noise interference	**Section 6.1**
		Chemical and terrestrial discharge	**Section 6.6 6.7 6.4 7.3 7.4 7.6 – 7.10**
		Marine debris	**Section 7.3 7.4**
		Loss of habitat	**Section 7.3 7.4 7.6 – 7.10**
		Vessel disturbance	**Section 7.2**
		Light pollution	**Section 6.2**
Fish and Sharks			
Whale shark	Approved Conservation Advice for *Rhincodon typus* (whale shark) (2015)	Marine debris	**Section 7.3 7.4**
		Boat strike from large vessel	**Section 7.2**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
	Whale shark management with particular reference to Ningaloo Marine Park, Wildlife Management Program no. 57 (2013)		
Grey nurse shark (west coast population)	Recovery Plan for the Grey Nurse Shark (Carcharias taurus) (2014)	Ecosystem effects as a result of habitat modification and pollution effects	**Section 7.3 7.4 7.6 – 7.10**
	Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (2018)	Marine debris	**Section 7.3 7.4**
White shark	Recovery Plan for the White Shark (Carcharodon carcharias) (2013)	Ecosystem effects as a result of habitat modification	**Section 7.3 7.4 7.6 – 7.10**
Dwarf sawfish	Commonwealth Conservation Advice on Pristis clavata (dwarf sawfish) (2009) Sawfish and River Sharks Multispecies Recovery Plan (2015)	Habitat degradation and modification	**Section 7.3 7.4 7.6 – 7.10**
Freshwater/Largetooth Sawfish	Approved Conservation Advice for *Pristis pristis* (largetooth sawfish) (2014) Sawfish and River Sharks Multispecies Recovery Plan (2015)	Habitat degradation and modification	**Section 7.3 7.4 7.6 – 7.10**
Green sawfish	Commonwealth Conservation Advice on Pristis zijsron (green sawfish) (2008) Sawfish and River Sharks Multispecies Recovery Plan (2015)	Habitat degradation and modification	**Section 7.3 7.4 7.6 – 7.10**
Northern River Shark	Approved Conservation Advice for *Glyphis garricki (northern river shark)* (2014) Sawfish and River Sharks Multispecies Recovery Plan (2015)	Habitat degradation and modification	**Section 6.4 7.3 7.4 7.6 – 7.10**

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Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
Blind Gudgeon	Approved Conservation Advice for Ilyeringa veritas (2008)	Habitat degradation and modification	**Section 6.4 7.3 7.4 7.6 – 7.10**
Balston's Pygmy Perch	Approved Conservation Advice for Nannnatherina balstoni (2008)	Habitat degradation and modification	**Section 6.4 7.3 7.4 7.6 – 7.10**
Blind cave eel	Approved Conservation Advice for Ophisternon candidum	Habitat degradation and modification	**Section 6.4 7.3 7.4 7.6 – 7.10**
Birds			
Red knot	Approved Conservation Advice for *Calidris canutus* (red knot) (2016)	Habitat loss and degradation	**Section 7.3 7.4 7.6 – 7.10**
		Pollution/contamination impacts	**Section 7.3 7.4 7.6 – 7.10**
Southern giant-petrel	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011) Background paper, population status and threats to albatrosses and giant petrels listed as threatened under the EPBC Act 1999 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Northern giant-petrel	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011) Background paper, population status and threats to albatrosses and giant petrels listed as threatened under the EPBC Act 1999 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
Curlew sandpiper	Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015)	Habitat loss and degradation from pollution	**Section 7.3 7.4 7.6 – 7.10**
Eastern curlew	Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015)	Habitat loss and degradation from pollution	**Section 7.3 7.4 7.6 – 7.10**
Western Alaskan Bar-tailed godwit	Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016)	Habitat loss and degradation	**Section 7.3 7.4 7.6 – 7.10**
		Pollution/contamination impacts	
Northern Siberian bar-tailed godwit	Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016)	Habitat loss and degradation	**Section 7.3 7.4 7.6 – 7.10**
		Pollution/contamination impacts	**Section 7.3 7.4 7.6 – 7.10**
Australian fairy tern	Commonwealth Conservation Advice on *Sternula nereis nereis* (fairy tern) (2011)	Oil spills	**Section 7.3 7.4 7.6 – 7.10**
Campbell Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Indian yellow-nosed albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Shy albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
White-capped albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Black-browed albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
White-winged fairy wren	Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Australian Lesser Noddy	Approved Conservation Advice for *Anous tenuirostris melanops* (Australian lesser noddy) (2015)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Christmas Island Frigatebird	National recovery plan for the Christmas Island Frigatebird (*Fregata andrewsi*) (2004)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Australasian Bittern	Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern) (2011)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Great Knot	Approved Conservation Advice for *Calidris tenuirostriss* (Great knot) (2016)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Greater Sand Plover	Approved Conservation Advice for *Charadrius leschenaultii* (Greater sand plover) (2016)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Lesser Sand Plover	Approved Conservation Advice for *Charadrius mongolus* (Lesser sand plover) (2016)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
Amsterdam Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Tristan Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Southern Royal Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Wandering Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Northern Royal Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Blue Petrel	Approved Conservation Advice for *Halobaena caerulea* (blue petrel) (2015)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Fairy Prion (southern)	Approved Conservation Advice for *Pachyptila turtur subantarctica* (fairy prion (southern)) (2015)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Abbott's Booby	Approved Conservation Advice for *Papasula abbotti* (Abbott's booby) (2015)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Christmas Island White-tailed Tropicbird	Conservation Advice for *Phaethon lepturus fulvus* white-tailed tropicbird (Christmas Island) (2014)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**

Name	Recovery Plan / Conservation Advice/Management Plan	Threats/strategies identified as relevant to the activity	Addressed in EP Section
Sooty Albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine pollution	**Section 7.3 7.4 7.6 – 7.10**
Soft-plumaged Petrel	Approved Conservation Advice for *Pterodroma mollis* (soft-plumaged petrel) (2015)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**
Australian Painted Snipe	Commonwealth Conservation Advice on *Rostratula australis* (Australian Painted Snipe) (2013)	Habitat Loss, Disturbance and Modification	**Section 7.3 7.4 7.6 – 7.10**

3.2.5 Socio-Economic

EPBC PMST searches (**Appendix D2** and **D3**) of the operational area (including the PW mixing zone) and the EMBA identified World Heritage, Commonwealth Heritage and National Heritage places which have been described in **Appendix D1**.

Socio-economic activities that may occur within the EMBA include commercial fishing, oil and gas exploration and production, recreational fishing and tourism as summarised in **Table 3-9**. A 500 m radius PSZ that extends around the DTM buoy will be maintained and enforced. All vessels, except for the vessels associated with the NV Operations, will be required to stay outside this zone.

Table 3-9 provides a summary of values within the operational area, PW mixing zone and EMBA that are potentially sensitive to the effects of a disturbance arising planned and unplanned NV Operations (refer **Section 6** and **Section 7**).

Table 3-9: Socio-Economic Activities within the Operational Area, PW mixing zone and EMBA

Value/ Sensitivity	Description	Operational Area and PW Mixing Zone Presence	EMBA Presence	Relevant Events within Operational Area	Relevant Events within the EMBA
Commonwealth Fisheries (**Section 3.2.5.1**): For full list of fisheries see **Table 3-9**	Five Commonwealth fisheries exist within the EMBA. No active commercial fishing within the operational area in the past years.	Yes (see **Table 3-9**)	Yes	Interaction with Other Marine Users (**Section 6.5**)	Hydrocarbon releases (**Section 7.6 – 7.10**)
State-Managed Fisheries (**Section 3.2.5.1**): For full list of fisheries see **Table 3-9**	46 State Managed Fisheries exist within the EMBA. No active commercial fishing within the operational area in the past years.	Yes (see **Table 3-9**)	Yes	Interaction with Other Marine Users (**Section 6.5**)	
Shipping (**Section 3.2.5.3**)	Shipping occurs in the vicinity of the operational area. Shipping using North West Shelf waters includes iron ore carriers, oil tankers and other vessels proceeding to or from the ports of Dampier, Port Walcott and Port Hedland; however, these are predominantly heading north from these ports.	Yes – However, no designated shipping route within operational area with the nearest located approximately 40 km northwest, other vessels may wish to transit the area although shipping traffic excluded from the 500 m PSZ.	Yes	Interaction with Other Marine Users (**Section 6.5**)	
Recreational fishing	Recreational fishing occurs within the EMBA but given the water depths and distance from the nearest mainland, it is unlikely recreational fishing would occur in the vicinity of operations	No - None within or near the operational area. Water depth and distance from shore make recreational fisheries presence highly unlikely	Yes	N/A	

Value/ Sensitivity	Description	Operational Area and PW Mixing Zone Presence	EMBA Presence	Relevant Events within Operational Area	Relevant Events within the EMBA
Underwater heritage	No underwater heritage sites are within the operational area. Underwater heritage sites may occur within the wider EMBA.	No - None within or near the operational area	Yes	N/A	
Oil and gas (**Section 3.2.5.2**)	Given the water depths and distance from the nearest mainland, it is unlikely recreational fishing would occur in the vicinity.	No – Oil and gas activities exist nearby the operational area although operational area represents a 500 m radius Exclusion Zone where no vessel incursions are permitted.	Yes	N/A	
Tourism	Owing to the water depths of the operational area, planned events are not predicted to have an impact on tourism.	No - None within operational area. Whale shark tours, fishing charters and whale watching tours all likely to occur closer to the mainland.	Yes	N/A	
Cultural Heritage	No known sites of Aboriginal Heritage significance occur within the operational area. Cultural heritage sites may occur within the wider EMBA.	No - None within or near the operational area	Yes	N/A	

3.2.5.1 Commercial Fisheries

A valuable and diverse commercial fishing industry is supported by both the offshore and coastal waters in the NWS Region, mainly dominated by the Pilbara fisheries. The major fisheries in the Pilbara region target tropical finfish, large pelagic fish species, crustaceans (prawns and scampi) and pearl oysters. A summary of commercial fisheries in the vicinity of the operational area, PW mixing zone and EMBA are provided in **Table 3-10** and visually in **Figure 3-13** to **Figure 3-15.**

These NWS region fisheries are managed by either the Department of Primary Industries and Regional Development (DPIRD) (State fisheries) with specific management plans, regulations and a variety of subsidiary regulatory instruments under the *Fish Resources Management Act 1994*, or by Australian Fisheries Management Authority (AFMA) that manage Commonwealth fisheries (within the 200 nautical mile Australian Fishing Zone).

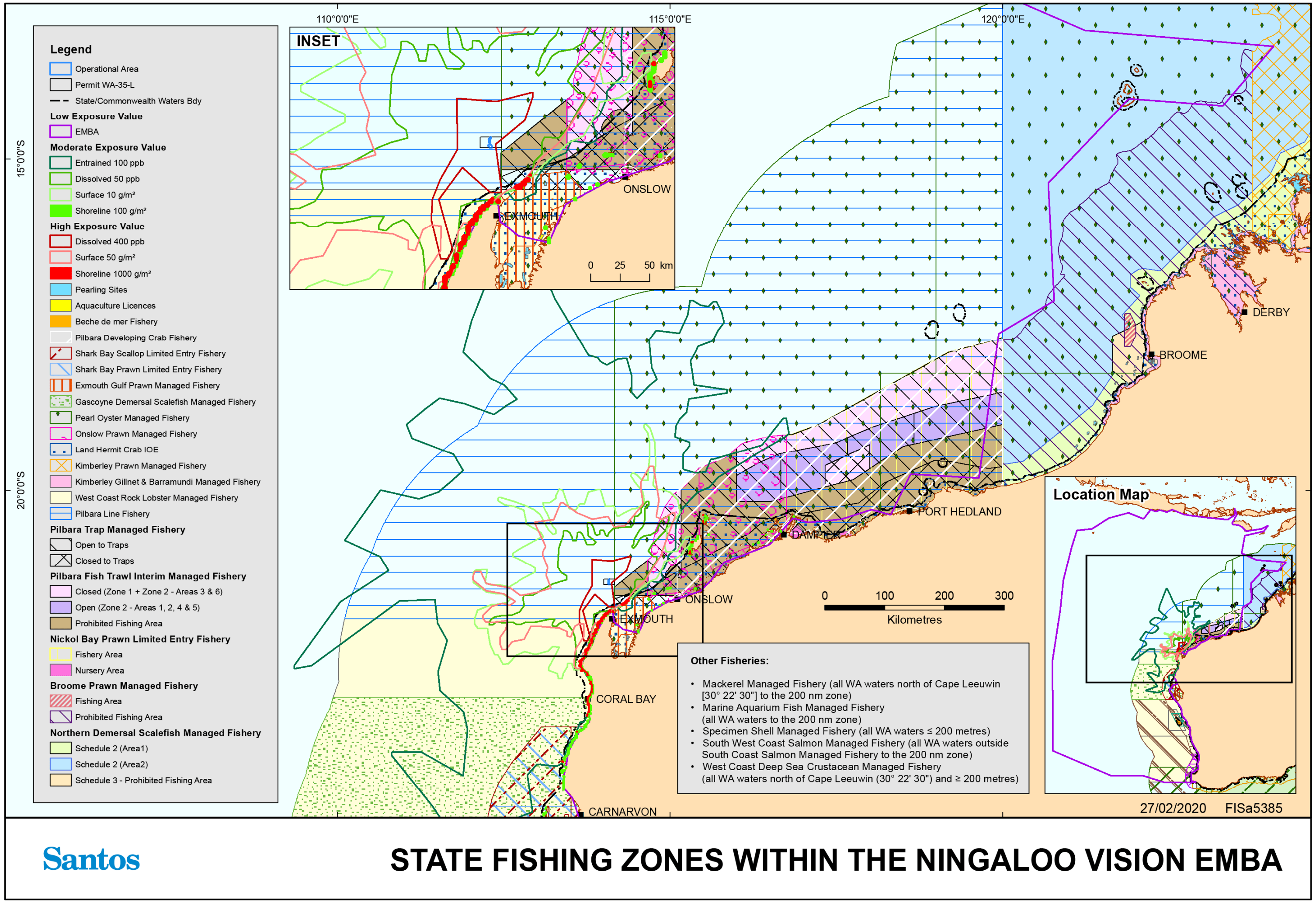

Figure 3-13: State Fishing Zones within the Vicinity of the NV Operations

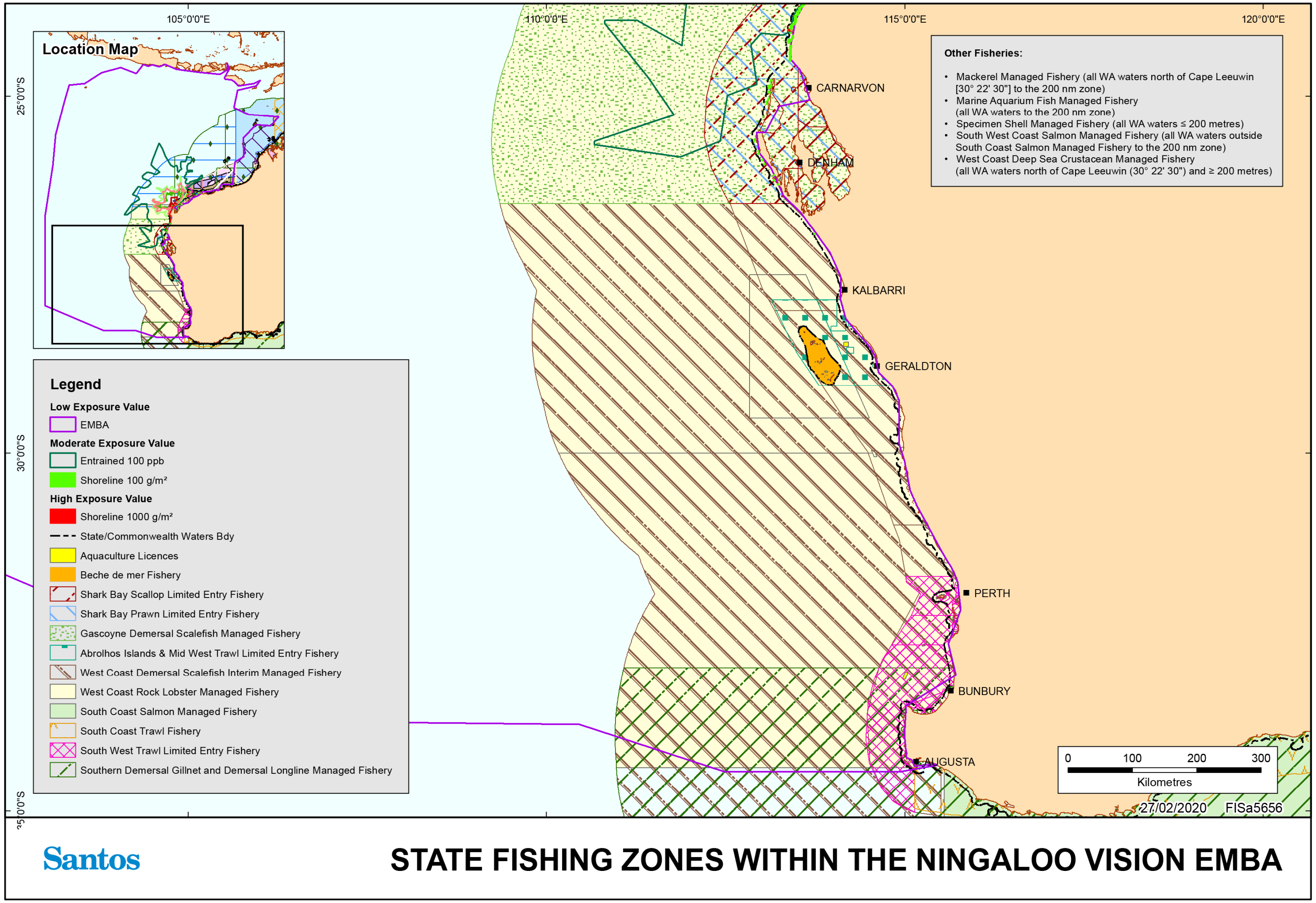

Figure 3-14: State Fishing Zones within the vicinity of the NV Operations

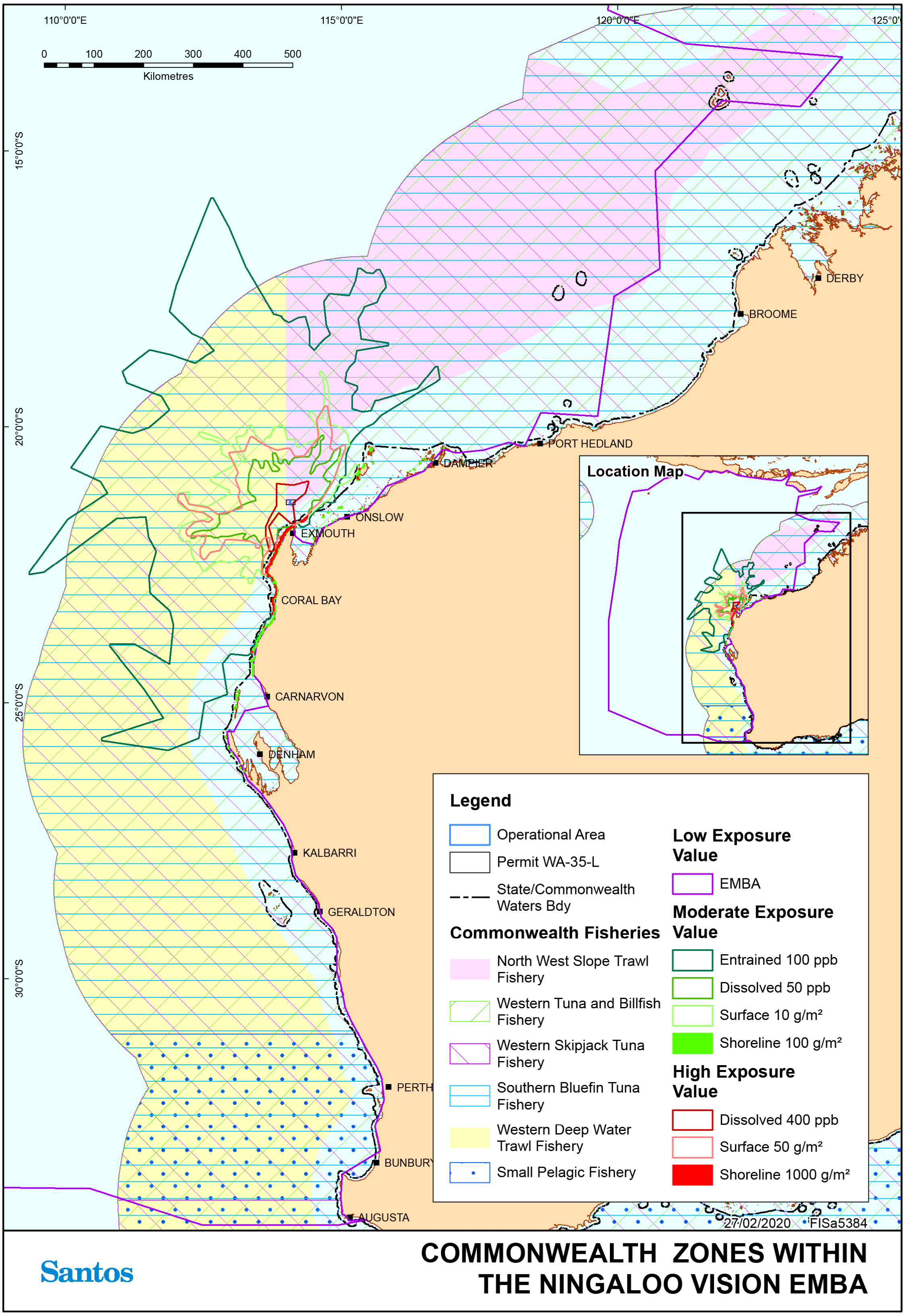

Figure 3-15: Commonwealth Fishing Zones within the Vicinity of the NV Operations

Table 3-10: State and Commonwealth Fisheries in the Vicinity of the Operational Area and EMBA

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
State Managed Fisheries							
Pilbara Line Managed Fishery	Variety of demersal scalefish including goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*), bluespotted emperor (*Lethrinus punctulatus*), crimson snapper (*Lutjanus erythropterus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor	2017/2018: 50–115 tonnes	Line	The Pilbara Trap Managed Fishery lies north of latitude 21°44´ S and between longitudes 114°9´36´´ E and 120° E on the landward side of a boundary approximating the 200 m isobath and seaward of a line generally following the 30 m isobath.	✓	✓	**No** The fishery has not been active in the Operational Area within the last five years. Water depths in the operational area are not conducive for this fishery. Fishing generally in shallower waters.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	(*Lethrinus nebulosus*) and frypan snapper (*Argyrops spinifer*), Ruby snapper (*Etelis carbunculus*) and eightbar grouper (*Hyporthodus octofasciatus)*						
Marine Aquarium Fish Managed Fishery (MAFMF)	Over 250 target species of finfish. (228 species caught in 2012). Fishermen can also take coral, live rock, algae, seagrass and invertebrates. The main fish species landed in 2012 were scribbled angelfish (*Chaetodontoplus duboulayi*) and green chromis (*Chromis cinerascens*) The main coral species landed in 2012 were the coral like	2017/2018: Total catch of 150,544 fishes, 21.9 t of coral, live rock & living sand and 322 L of marine plants.	Hand harvest while diving or wading. Hand held nets	Dive based fishery operating all year throughout WA waters, but restricted by diving depths. The MAFMF is able to operate in all State waters (between the Northern Territory border and South Australian border). The fishery is typically more active in waters south of Broome with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth and Dampier. Operators in the MAFMF are also permitted to take coral, live rock, algae, seagrass and invertebrates under the Prohibition on Fishing (Coral, 'Live Rock' and Algae) Order 2007 and by	✓	✓	**No** The fishery has not been active in the Operational Area within the last five years. Water depths in the operational area are not conducive for this fishery. Fishing generally in shallower waters.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	anemones of the Corallimorpharia.			way of Ministerial Exemption (Gaughan & Santoro, 2018).			
Mackerel Managed Fishery (Area 2)	Spanish and grey mackerel	Trawling or handline year round in all waters to the 200 nautical mile AFZ between 114° E to 121°. Fishing effort recorded within EMBA for Area 2 (Pilbara). No effort at operational area and PW mixing zone due to offshore location and depth of these areas (>300 m	Trolling or handline	The Fishery extends from the West Coast Bioregion to the WA/NT border, to the 200 nautical mile AFZ with most effort and catches recorded north of Geraldton, especially from the Kimberley and Pilbara coasts of the Northern Bioregion. Restricted to coastal and shallower waters. The operational area for this activity does intersect the Mackerel Managed Fishery Area 2.	✓	✓	**No** The fishery has not been active in the Operational Area within the last five years. Water depths in the operational area are not conducive for this fishery. Fishing generally in shallower waters.
Specimen Shell Managed Fishery (SSF)	Shells (cowries, cones) The Specimen Shell Managed Fishery (SSF) is based on the collection of individual shells for the purposes of display, collection, cataloguing,	2017/2018: 7,806 shells	Hand harvest while diving or wading along coastal beaches below the high water mark An exemption method being employed by the fishery is using a remote controlled underwater	Dive based fishery operating all year throughout WA waters, but restricted by diving depths. The fishing area includes all Western Australian waters between the highwater mark and the 200 m isobath. While the fishery covers the entire WA coastline, there is some concentration of effort	✓	✓	**No** The fishery has not been active in the Operational Area within the last five years. Water depths in the operational area are not conducive for this fishery. Fishing generally in shallower waters.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	classification and sale. Just under 200 (196) different Specimen Shell species were collected in 2012, using a variety of methods.		vehicle at depths between 60 and 300 m.	in areas adjacent to population centres such as Broome, Karratha, Exmouth, Shark Bay, metropolitan Perth, Mandurah, the Capes area and Albany.			
South West Coast Salmon Managed Fishery	WA salmon (*Arripis truttaceus*)	Insufficient information	Insufficient information	Description: The South West Coast Salmon Managed Fishery operates on various beaches south of the metropolitan area and includes all Western Australian waters north of Cape Beaufort except Geographe Bay. This fishery uses beach seine nets to take western Australian salmon (Arripis truttaceus). No fishing takes place north of the Perth metropolitan area, despite the managed fishery boundary extending to Cape Beaufort (Western Australia/Northern Territory border).	✓	✓	**No** No fishing takes place north of the Perth metropolitan area, despite the managed fishery boundary extending to Cape Beaufort (Western Australia/Northern Territory border).
Abrolhos Islands and Mid-West Trawl Managed	Saucer scallops (*Ylistrum balloti*), with a small component targeting the	2017/2018: 651 tonnes	Operates using low opening otter trawl systems.	All the waters of the Indian Ocean adjacent to Western Australia between 27°51´ south latitude and 29°03´ south latitude on the	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
Fishery (AIMWTMF)	western king prawn (*Penaeus latisulcatus*)			landward side of the 200 m isobath'.			
Broome Prawn Managed Fishery (BPMF)	Western king prawns (*Penaeus latisulcatus*) and coral prawns (a combined category of small penaeid species).	Extremely low fishing effort occurred as only a single boat undertook trial fishing to investigate whether catch rates were sufficient for commercial fishing. This resulted in negligible landings of western king prawns with no byproduct recorded.	Otter trawl	The BPMF operates in a designated trawl zone off Broome. The boundaries of the BPMF are 'all Western Australian waters of the Indian Ocean lying east of 120° east longitude and west of 123°45' east longitude on the landward side of the 200 m isobath'. The actual trawl area is contained within a delineated small area north west of Broome.	X	✓	N/A
Cockburn Sound Mussel Managed Fishery	Blue mussels (*Mytilus edulis*)	2015: Unspecified	Agriculture	Main mussel farming occurs in southern Cockburn Sound.	X	✓	N/A
Cockburn Sound Crab Managed Fishery	Blue Swimmer (*Portunus armatus)* Blue swimmer crab (*Portunus armartus)*	2017/2018: 5: closed to commercial and recreational fishing since April 2014	Drop nets, scoop nets, diving	Encompasses the inner waters of Cockburn Sound, from South Mole at Fremantle to Stragglers Rocks, through Mewstone to Carnac Island and Garden	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
				Island, along the eastern shore of Garden Island and back to John Point on the mainland.			
Cockburn Sound Line and Pot Managed Fishery	Southern garfish (*Hyporhamphus melanochir*), Australian herring (*Arripis geogianus*)	2017/2018: 257 tonnes	Line (fish) Shelter and trigger pots (octopus)	Encompasses the inner waters of Cockburn Sound, from South Mole at Fremantle to Stragglers Rocks, through Mewstone to Carnac Island and Garden Island, along the eastern shore of Garden Island and back to John Point on the mainland.	X	✓	N/A
Exmouth Gulf Prawn Managed Fishery	Western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.) and banana prawns (*Penaeus merguiensis*).	2017/2018: 713 tonnes	Low opening otter trawls.	Sheltered waters of Exmouth Gulf Essentially the western half of the Exmouth Gulf (eastern part is a nursery ground). The Muiron Islands and Point Murat provide the western boundary; Serrurier Island provides the northern limit	X	✓	N/A
Gascoyne Demersal Scalefish Managed Fishery (GDSMF)	Targets pink snapper (*Pagrus auratus*) and goldband snapper (*Pristipomoides multidens*).	2017/2018: Snapper: 133 tonnes Other demersals: 144 tonnes	Mechanised handlines	The GDSF operates in the waters of the Indian Ocean and Shark Bay between latitudes 23°07'30"S and 26°30'S. Vessels are not	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	Other demersal species caught include the rosy snapper (*P. filamentosus*), ruby snapper (*Etelis carbunculus*), red emperor (*Lutjanus sebae*), emperors (Lethrinidae, including spangled emperor, *Lethrinus nebulosus*, and redthroat emperor, *L. miniatus*), cods (Epinephelidae, including Rankin cod, *Epinephelus multinotatus* and goldspotted rockcod, *E. coioides*), pearl perch (*Glaucosoma burgeri*), mulloway (*Argyrosomus japonicas*), amberjack			permitted to fish in inner Shark Bay.			

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	(*Seriola dumerili*) and trevallies (Carangidae).						
Abalone Managed Fishery	Greenlip abalone (*Haliotis laevigata*) Brownlip abalone (*H. conicopora)*	2017/2018: 98 tonnes	Dive fishery The principal harvest method is a diver working off 'hookah' (surface supplied breathing apparatus) or SCUBA using an abalone 'iron' to prise the shellfish off rocks – both commercial and recreational divers employ this method.	Shallow coastal waters off the south-west and south coasts of Western Australia Covers all Western Australian coastal waters, which are divided into eight management areas. Commercial fishing for greenlip/brownlip abalone is managed in three separate areas.	X	✓	N/A
Hermit Crab Fishery (HCF)	Australian land hermit crab (*Coenobita variabilis*)	2017/2018: 58,643 (lowest reported in the last 10 years (2008-2017; catch range 58,643-118,203).	Land based hand collection typically using four-wheel drives to access remote beaches	Operates in Western Australian waters north of the Exmouth Gulf (22°30'S)	X	✓	N/A
Kimberley Developing Mud Crab Managed Fishery	Mud crab (*Scylla serrata*)	2017/2018: 60 tonnes (also includes catch data from Pilbara	Mud Crab traps	This fishery operates between Broome and Cambridge Gulf. Three commercial operators are permitted to fish from	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
		Developmental crab fishery)		King Sound to the Northern Territory border, with closed areas around communities and fishing camps. One Aboriginal Corporation is permitted to fish in King Sound, with the other Aboriginal Corporation permitted to fish in a small area on the western side of the Dampier peninsula, north of Broome. Notices issued under the *Fish Resources Management Act 1994* prohibit all commercial fishing for mud crabs in Roebuck Bay and an area of King Sound near Derby.			
Mandurah to Bunbury Developing Crab Fishery	Blue swimmer crab (*Portunus armartus)*	2017/2018: 5.2 tonnes	Drop nets, scoop nets, diving	Fishery extends from south of the Shoalwater Islands Marine Park (32°22'40''S) to Point McKenna near Bunbury (33°16'S) and offshore to 115°30'E. The fishery is divided into two zones with crab fishing historically being permitted within Area 1, Comet Bay between 32°22''40''S and 32°30'S, and Area 2, Cape Bouvard to the southern boundary of the fishery.	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
				In 2015 crab fishing within Area 2 ceased.			
Nickol Bay Prawn Managed Fishery (NBPMF)	Primarily targets banana prawns (*Penaeus merguiensis*)	2017/2018: 227 tonnes	Otter trawl	Operates along the western part of the North-West Shelf in coastal shallow waters The boundaries of the NBPMF are 'all the waters of the Indian Ocean and Nickol Bay between 116°45' east longitude and 120° east longitude on the landward side of the 200 m isobath'. The NBPMF incorporates the Nickol Bay, Extended Nickol Bay, Depuch and De Grey size managed fish grounds (State of the Fisheries 2014-15).	X	✓	N/A
North Coast Trochus Fishery	Trochus (*Tectus niloticus*)	2017/2018: Unspecified	Harvested by with handheld levers or chisels	Indigenous fishery operating within King Sound	X	✓	N/A
Northern Demersal Scalefish Managed Fishery (NDSF)	Red emperor (*Lutjanus sebae*) Goldband snapper (*Pristipomoides multidens*)	2017/2018:1317 tonnes (total) Goldband snapper (not including other jobfish): 473 tonnes Red emperor: 34 – 47 tonnes	The permitted means of operation within the fishery include handline, dropline and fish traps, but since 2002 it has essentially been a trap-based fishery which	The Northern Demersal Scalefish Managed Fishery (NDSF) operates off the northwest coast of Western Australia in the waters east of 120° E longitude. These waters extend out to the edge of the Australian Fishing Zone (200 nautical miles).	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
			uses gear time access and spatial zones as the primary management measures (State of the Fisheries 2014-15).	The Fishery consists of three zones; Zone A is an inshore area, Zone B comprises the area with most historical fishing activity and Zone C is an offshore deep slope developmental area. The fishery is further divided into two fishing areas; an inshore sector and an offshore sector. The inshore waters in the vicinity of Broome are closed to commercial fishing.			
WA North Coast Shark Fisheries	Sandbar (*Carcharhinus plumbeus*), hammer head (*Sphyrnidae*), blacktip (*Carcharhinus melanopterus*) and lemmon sharks (*Negaprion brevirostris*).	2017/2018: closed since 2008/2009	Gill net, longline	Comprised of 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.	X	✓	N/A
Octopus Interim Managed Fishery	*Octopus cf. tetricus*, with occasional bycatch of *O. ornatus* and *O. cyanea* in the	2017/2018: Commercial: 257 tonnes Recreational: 1 tonne	Line and pots Trawl and trap (land Octopus as byproduct)	Fishery in development phase. Four main categories in WA waters. Octopus are primarily caught in the Developing Octopus Interim Managed Fishery (largest	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	northern parts of the fishery, and *O.maorum* in the southern and deeper sectors.			fishery) are limited to the boundaries of the developmental fishery, which is an area bounded by the Kalbarri Cliffs (26°30'S) in the north and Esperance in the south. Passive and by-product harvests of octopus occur in both the Cockburn Sound (Line and Pot) Managed Fishery and the West Coast Rock Lobster Managed Fishery.			
Onslow Prawn Managed Fishery (OPMF)	Western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.)	2017/2018: Negligible (Minimal fishing occurred in 2017)	Otter trawl	Operates along the western part of the North-West Shelf with most prawning activities concentrated in the shallower water off the mainland. The boundaries of the OPMF are 'all the Western Australian waters between the Exmouth Prawn Fishery and the Nickol Bay prawn fishery east of 114º39.9' on the landward side of the 200 m depth isobath'.	X	✓	N/A
Pilbara Demersal Scalefish	Variety of demersal scalefish including goldband snapper		Demersal trawl and trap in various zones	No fishing in operational area and PW mixing zone. Northern portion of EMBA	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
Fishery (Line, Trawl and Trap)	(*Pristipomoides multidens*), red emperor (*Lutjanus sebae*) and bluespotted emperor (*Lethrinus punctulatus*).		and operates year round.	overlies both trawl and trap areas.			
Pilbara Developmental Crab Fishery	Blue Swimmer (*Portunus armatus)* Mud Crab (*Scylla* spp)	2017/2018: 60 tonnes (total number includes Kimberley Developing Mud Crab Fishery)	Variety of gear but mostly commercial crab pots (Hourglass traps used in inshore waters from Onslow through to Port Hedland with most commercial and activity occurring in and around Nickol Bay) Recreational fishers use drop nets or scoop nets, with diving for crabs becoming increasingly popular	The majority of the commercially and recreationally-fished stocks are concentrated in the coastal embayments and estuaries between Geographe Bay in the south west and Nickol Bay in the north. Crabbing activity along the Pilbara coast is centred largely on the inshore waters from Onslow through to Port Hedland, with most commercial and recreational activity occurring in and around Nickol Bay.	X	✓	N/A
Pilbara Fish Trawl (Interim) Managed	Variety of demersal scalefish	2017/2018: 1,780 tonnes	Demersal trawl	The Pilbara Fish Trawl (Interim) Managed Fishery is situated in the Pilbara	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
Fishery (PFTIMF)	including goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*), bluespotted emperor (*Lethrinus punctulatus*), crimson snapper (*Lutjanus erythropterus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor (*Lethrinus nebulosus*) and frypan Moses' snapper (*Argyrops Lutjanusspinifer russelli*).			region in the north west of Australia. It occupies the waters north of latitude 21°35'S and between longitudes 114°9'36"E and 120°E. The Fishery is seaward of the 50 m isobath and landward of the 200 m isobath. The Fishery consists of two zones; Zone 1 in the south west of the Fishery (which is closed to trawling) and Zone 2 in the North, which consists of six management areas.			

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
Pilbara Trap Managed Fishery (PTMF)	Blue-spot emperor (*Lethrinus hutchinsi*), Red snapper (*Lutjanus erythropterus*), Goldband snapper (*Pristipomoides multidens*), Scarlet perch (*Lutjanus malabaricus*), Red emperor (*Lutjanus sebae*), Spangled emperor (*Lethrinus nebulosus*), Rankin cod (*Epinephelus multinotatus*)	2017/2018: 400–600 tonnes	Use of rectangular traps with single opening and 50 mm x 70 mm rectangular mesh panels. Trap fishing normally targets areas around rocky outcrops and reefs	Permitted to operate within waters bounded by a line commencing at the intersection of 21°56´ S latitude and the high water mark on the western side of the North West Cape.	X	✓	N/A
Pilbara Line Managed Fishery	Variety of demersal scalefish including goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*), bluespotted emperor	2017/2018: 50–115 tonnes	Line	The Pilbara Trap Managed Fishery lies north of latitude 21°44´ S and between longitudes 114°9´36´´ E and 120° E on the landward side of a boundary approximating the 200 m isobath and seaward of a line generally following the 30 m isobath.	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	(*Lethrinus punctulatus*), crimson snapper (*Lutjanus erythropterus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor (*Lethrinus nebulosus*) and frypan snapper (*Argyrops spinifer*), Ruby snapper (*Etelis carbunculus*) and eightbar grouper (*Hyporthodus octofasciatus)*						
Roe's Abalone	Western Australian Roe's abalone (*Haliotis roei*)	2017/2018: Commercial: 49 tonnes	Dive and wade fishery. The commercial fishery harvest method is a	Operating in shallow coastal waters along WA's western and southern coasts from Shark Bay to the SA border. Divided into 8 management	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
		Recreational: 23 tonnes	single diver working off a 'hookah' (surface-supplied breathing apparatus) using an abalone 'iron' to prise the shellfish off rocks. Abalone divers operate from small fishery vessels (generally less than 9 metres in length).	areas. Commercial fishing for Roe's abalone is managed in 6 separate regions from the South Australian border to Busselton Jetty – Areas 1, 2, 5, 6, 7 and 8. Area 8 of the fishery was not fished in 2013.			
Shark Bay Crab Interim Managed Fishery	Blue swimmer crab (*Portunus armatus*)	2017/2018: 443 tonnes total Crab: 153 tonnes	Trawl and trap	Waters of Shark Bay north of Cape Inscription, to Bernier and Dorre Islands and Quobba Point. In addition, two fishers with long-standing histories of trapping crabs in Shark Bay are permitted to fish in the waters of Shark Bay south of Cape Inscription.	X	✓	N/A
Shark Bay Prawn Managed Fishery	Western king prawn (*Penaeus latisulcatus*), brown tiger prawn (*Penaeus esculentus*), Variety of smaller	2017/2018: 1,608 tonnes	Low opening otter trawls	The boundaries of the Shark Bay Prawn Managed Fishery are located in and near the waters of Shark Bay	X	✓	N/A

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Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	prawn species including endeavour prawns (*Metapenaeus* spp.) and coral prawns (various species).						
Shark Bay Scallop Managed Fishery	Saucer Scallop (*Ylistrum balloti*)	2017/2018: 1,632 tonnes	Low opening otter trawls	The boundaries of the Shark Bay Scallop Managed Fishery are located in and near the waters of Shark Bay	X	✓	N/A
South Coast Open Access Netting Fishery	Insufficient information	Insufficient information	Insufficient information	Bunbury to the South Australian Border	X	✓	N/A
South West Coast Beach Net	Insufficient information	Insufficient information	Insufficient information	Insufficient information	X	✓	N/A
South West Trawl Managed Fishery (SWTMF)	Saucer scallops (*Ylistrum balloti*)	2017/2018: 460 t meat weight (2,301 t whole weight)	Otter trawls	Waters between 31°34'27''S and 115°8'8''E where it intersects with the high water mark at Cape Leeuwin and on the landward side of the 200 m isobath.	X	✓	N/A
Temperate Demersal Gillnet and Demersal Longline	Gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark	2017/2018: 2016-17Sharks and rays: 936 tonnes Scalefish: 133 tonnes	Demersal gillnets and power-hauled reels (to target sharks) Demersal longline	The Temperate Demersal Gillnet and Demersal Longline fisheries consists of Zone 1 of the Joint Authority Southern Demersal Gillnet and Demersal Longline	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
Fisheries (TDGDLF)	(*Furgaleus macki*) and sandbar shark (*Carcharhinus plumbeus*).			Managed Fishery and the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery. The Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLF) spans the waters from 33° S latitude to the WA/SA border and comprises three management zones Zone 1 extends southwards from 33° S to 116° 30' E longitude off the south coast. Zone 2 extends from 116°30' E to the WA/SA border (129° E). A small number of Zone 3 units permit fishing throughout Zone 1 and eastwards to 116° 55'40" E. The West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF) technically extends northwards from 33° S latitude to 26° S longitude. However, the use of shark fishing gear has been prohibited north of 26° 30' S (Steep Point) since 1993.			

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
				Demersal gillnet and longline fishing inside the 250 metre depth contour has been prohibited off the Metropolitan coast (between latitudes 31° S and 33° S) since November 2007.			
Warnbro Sound Crab Managed Fishery	Blue Swimmer (*Portunus armatus)* Blue swimmer crab (*Portunus armartus)*	2017/2018: closed to commercial and recreational fishing	Drop nets, scoop nets, diving	Includes Warnbro sound and adjacent water, extending from Becher Point to John Point.	X	✓	N/A
West Coast Deep Sea Crustacean (Interim) Managed Fishery	Crystal (Snow) crabs (*Chaceon albus*), Giant (King) crabs (*Pseudocarcinus gigas*) and Champagne (Spiny) crabs (*Hypothalassia acerba*).	2017/2018: 164.4 tonnes	Baited pots operated in a longline formation in the shelf edge waters (>150 m)	North of latitude 34° 24' S (Cape Leeuwin) and west of the Northern Territory border on the seaward side of the 150 m isobath out to the extent of the AFZ, mostly in 500 to 800 m of water.	X	✓	N/A
West Coast Demersal Scalefish (Interim) Managed Fishery	West Coast Inshore Demersals: West Australian Dhufish (*Glaucosoma hebraicum*), Pink snapper (*Pagrus auratus*) with	2017/2018: 248 tonnes	Handline and drop line	The WCDSIMF encompasses the waters of the Indian Ocean just south of Shark Bay (at 26°30'S) to just east of Augusta (at 115°30'E) and extends seaward to the 200 nm boundary of the Australian Fishing Zone (AFZ).	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	other species captured including Redthroat Emperor (*Lethrinus miniatus*), Bight Redfish (*Centroberyx gerrardi*) and Baldchin Groper (*Choerodon rubescens*). West Coast Offshore Demersals: Eightbar Grouper *Hyporthodus octofasciatus*, Hapuku *Polyprion oxygeneios*, Blue-eye Trevalla *Hyperoglyphe antarctica* and Ruby Snapper *Etelis carbunculus*.			The commercial fishery is divided into five management areas comprising four inshore areas and one offshore area. The inshore areas, i.e. Kalbarri, Mid-West, Metropolitan and South-West, extend outwards to the 250 m depth contour, while the Offshore Area extends the entire length of the fishery from the 250 m depth contour to the boundary of the AFZ.			
West Coast Estuarine Managed Fishery	Blue swimmer crab (*Portunus armartus)*	2017/2018: 353 tonnes (blue swimmer crab) commercial and	Drop nets, scoop nets, diving (crabs)	Includes the waters of the Swan and Canning Rivers (Area 1), the waters of the Peel Inlet and Harvey Estuary, together with the Murray Serpentine, Harvey	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
		58-77 tonnes recreational		and Dandalup Rivers (Area 2) and waters of the Hardy Inlet (Area 3). Of these areas only Areas 1-2 are permitted for crab fishing.			
West Coast Nearshore and Estuarine Finfish Fisheries	Nearshore: whitebait (*Hyperlophus vittatus*), western Australian salmon (*Arripis truttaceus*), Australian herring (*Arripis georgianus*), southern school whiting (*Sillago bassensis*), yellowfin whiting (*Sillago schomburgkii*), yelloweye mullet (*Aldrichetta forsteri*), tailor (*Pomatomus saltarix*), southern garfish (*Hyporhamphus melanochir*), silver trevally (*Pseudocaranx georgianus*) and King George	2017/2018: 353 tonnes	Haul, beach seine and gill netting (commercial). Line fishing (recreational)	Five commercial fisheries target nearshore and/or estuarine finfish in the West Coast Bioregion. Nearshore: Cockburn Sound Fish Net Managed Fishery operating within in Cockburn sound, South West Coast Salmon Managed Fishery operating on various beaches south of the Perth Metropolitan area, West Coast Beach Bait Managed Fishery operating on beaches spanning from Moore River to Tim's Thicket and the South West Beach Seine Fishery operating on various beaches from Tim's Thicket southwards to Port Geographe Bay Marina. Estuarine: West Coast Estuarine Managed Fishery operating in the Swan/Canning and Peel Harvey estuaries, and in the Hardy Inlet	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	whiting (*Sillaginodes punctate*). Estuarine: sea mullet (*Mugil cephalus*), estuary cobbler (*Cnidoglanis macrocephalus*) and black bream (*Acanthopagrus butcheri*).						
West Coast Nearshore Net Managed Fishery	Southern garfish (Hyporhamphus melanochir), Australian herring (Arripis georgianus),	Insufficient information	Insufficient information	Insufficient information	X	✓	N/A
West Coast Purse Seine Fishery	Scaly mackerel (*Sardinella lemuru*), pilchard (*S. sagax*), Australian anchovy (*Engraulis australis*), yellowtail scad (*Trachurus novaezelandiae*) and maray (*Etrumeus teres*).	2017/2018: 1,095 tonnes	Purse seine gear	Waters between Ningaloo and Cape Leeuwin including three separate zones: Northern Development (22°00'S to 31°00'S), Perth Metropolitan (31°00'S to 33°00'S) and Southern Development Zone (33°00'S to Cape Leeuwin).	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
West Coast Rock Lobster Managed Fishery (WCRLMF)	Western rock lobster (*Panulirus cygnus*)	2016: 272 – 400 tonnes (346-481 tonnes based on updated average weight)	Baited traps (pots). Pots and diving (recreational catch)	The fishery is situated along the west coast of Australia between Latitudes 21°44´ to 34°24´ S. The fishery is managed in three zones: Zone A – Abrolhos Islands, north of latitude 30° S excluding the Abrolhos Islands (Zone B) and south of latitude 30° S (Zone C).	X	✓	N/A
West Coast Demersal Gillnet and Demersal Longline (WCDGDLF)*	Gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*C. plumbeus*)	2016/2018: 936 tonnes of sharks and rays	Demersal gillnets and demersal longline (not widely used)	Operates between 26° and 33° S.	X	✓	N/A
Mackerel Fishery	Spanish mackerel *(Scomberomorus commerson)*, grey mackerel *(S.semifasciatus)*, with other species from the genera *Scomberomorus*, *Grammatorcynus* and *Acanthocybium* also contributing	2016: Commercial: The commercial catch of spanish mackerel was 276 tonnes in 2016 (Gaughan & Santoro, 2018)	Trolling or handline Near-surface trolling gear from vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture	The Fishery extends from the West Coast Bioregion to the WA/NT border, to the 200 nautical mile AFZ with most effort and catches recorded north of Geraldton, especially from the Kimberley and Pilbara coasts of the Northern Bioregion. Restricted to coastal and shallower waters.	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	to commercial catches.		grey mackerel *(S.semifasciatus)*	Catches are reported separately for three Areas: Area 1 - Kimberley (121º E to WA/NT border); Area 2 -Pilbara (114º E to 121º E); Area 3 - Gascoyne (27º S to 114º E) and West Coast (Cape Leeuwin to 27º S).			
Western Australian Pearl Oyster Managed Fishery	Indo- Pacific silver-lipped pearl oyster (*Pinctada maxima*).	2018: 468,573 shells	Drift diving restricted to shallow diveable depths. The collection of pearl oysters for the Pearl Oyster Managed Fishery is restricted to shallow diving depths below 35 m. Divers are attached to large outrigger booms on a vessel and towed slowly over the pearl oyster beds, harvesting legalised oysters by hand as they are seen.	The fishery is separated into four zones: Pearl Oyster Zone 1: NW Cape (including Exmouth Gulf) to longitude 119°30'E. There are five licensees in this zone. No fishing in this zone since 2008 Pearl Oyster Zone 2: East of Cape Thouin (118°20´ E) and south of latitude 18°14´ S. The 9 licensees in this zone also have full access to Zone 3. This zone is the mainstay of the fishery. Pearl Oyster Zone 3: West of longitude 125°20´ E and north of latitude 18°14´ S. The 2 licensees in this zone also have partial access to Zone 2. Pearl Oyster Zone 4: East of longitude 125°20´ E to the	X	✓	N/A

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
				Western Australia/Northern Territory border. Although all licensees have access to this zone, exploratory fishing has shown that stocks in this area are not economically viable. However, pearl farming does occur.			
Western Australian Sea Cucumber Fishery (formerly known as Beche-de-mer)	Sandfish (*Holothuria scabra*) and deepwater redfish (*Actinopyga echinites*).	2016: 93 tonnes	Hand-harvest fishery, with animals caught principally by diving, and a smaller amount by wading.	The Western Australian Sea Cucumber Fishery is permitted to operate throughout WA waters with the exception of a number of specific closures around the Dampier Archipelago, Cape Keraudren, Cape Preston and Cape Lambert, the Rowley Shoals and the Abrolhos Islands. The fishery is primarily based in the northern half of the State, from Exmouth Gulf to the Northern Territory border.	X	✓	N/A
Commonwealth Managed Fisheries							
Western Skipjack Tuna Fishery	Skipjack tuna (*Katsuwonus pelamis*)	2017-18: None in either zones	No active commercial fishing within the operational area in the past years; however fisheries overlap	The Skipjack Tuna Fishery is split into two sectors; east and west. The Western Skipjack Tuna Fishery is located in all Australia waters west of 142° 30'	✓	✓	**No** Should the fishery recommence efforts in the future, fishing effort in the operational area and wider EMBA will not occur as historical fishing effort was concentrated off southern Australia

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
			the EMBA and therefore fishing vessels could be encountered in low density.	00ºE, out to 200 nm from the coast. There has been no fishing effort in the Skipjack Tuna Fishery since the 2008-09 season, and in that season activity concentrated off South Australia (Department of Agriculture 2019).			
Southern Bluefin Tuna Fishery	Southern bluefin tuna (*Thunnus maccoyii*).	2017-18: 6,159 tonnes	Purse seine vessels primarily in Great Australian Bight all year round and longline off southern NSW in winter. Around 98% of Australia's SBT quota is taken by 5–10 purse seine vessels fishing for 13–25 kg southern bluefin tuna.	Fishery includes all waters of Australia, out to 200 nm from the coast. No current effort on the North West Shelf, fishing activity is concentrated in the Great Australian Bight and off South-east Australia (Department of Agriculture 2019).	✓	✓	**No** Given the current distribution of fishing effort and fishing methods utilised by the industry, fishing for Bluefin tuna is unlikely to occur in the operational area.
Western Tuna and Billfish Fishery	Broadbill swordfish (*Xiphias gladius*), albacore tuna (*Thunnus alalunga*), striped marlin (*Kajikia audax*), bigeye	2018: 278 tonnes	Pelagic, longline, minor line and purse seine.	Extends westward from Cape York Peninsula (142°30' E) off Queensland to 34° S off the WA west coast. It also extends eastward from 34° S off the west coast of WA across the Great Australian Bight to	✓	✓	**No** Over the last five years, fishing effort has been concentrated south of the Operational Area. Fishing effort from 2014 to 2018 has been recorded from offshore Point Cloates (Exmouth) south along the WA coast to Augusta in the south-

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	tuna (*T. obesus*) and yellowfin tuna (*T. albacares*).			141° E at the South Australian–Victorian border. In recent years, fishing effort has concentrated off south-west Western Australia and South Australia with no current effort on the North West Shelf (Department of Agriculture 2019).			west of WA (ABARES, Williams et al., 2019).
North West Slope Trawl Fishery	Scampi (crayfish): velvet scampi (*Metanephrops velutinus*) and boschmai scampi (*Metanephrops boschmai*). Deepwater prawns (penaeid and carid): pink prawn (*Parapenaeus longirostris*), red prawn (*Aristaeomorpha foliacea*), striped prawn (*Aristeus virilis*), giant scarlet prawn (*Aristaeopsis edwardsiana*), red carid prawn (*Heterocarpus*	2015-16: 33 tonnes	Demersal trawl seaward of the 200 m isobath, but no current effort in vicinity of the operational area and PW mixing zone and limited effort within EMBA.	The North West Slope Trawl Fishery typically comprises one or two vessels each year. Fishing effort often increases when boats cease to operate in the Northern Prawn Fishery (ABARES Fishery Status Reports, 2019).	✓	✓	**No** Given the current distribution of fishing effort and number of vessels utilized by the industry, fishing is unlikely to occur in the operational area.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description	Operational Area	EMBA	Potential for interaction in the Operational Area
	woodmasoni) and white carid prawn (*Heterocarpus sibogae*).						
Western Deepwater Trawl Fishery	A diverse range of species are caught, ranging from tropical and ruby snappers on the shelf edge to orange roughy (*Hoplostethus atlanticus*), oreo dories and bugs (*Ibacus* spp.) in the deeper temperate waters.	2017-18: 101.9 tonnes	Demersal fish trawl seaward of the 200 m isobath.	Its northernmost point is from the boundary of the AFZ to longitude 114° E, and its southernmost point is from the boundary of the AFZ to longitude 115°08' E. Deep water off WA, from the 200 m isobath to the edge of the AFZ.	X	✓	N/A
Small Pelagic Fishery	Australian sardine (*Sardinops sagax*), blue mackerel (*Scomber australasicus*), jack mackerel (*Trachurus declivis*) and redbait (*Emmelichthys nitidus*).	2018-19: 9,424 tonnes	Midwater trawl, purse seine and jigging and minor line methods	Extends from Queensland to southern Western Australia.	X	✓	N/A

3.2.5.2 Petroleum Industry

The Exmouth region has a long history of oil and gas industry since oil was first discovered in the Rough Range field in 1953, 65 km south of Exmouth. Subsequently, the Exmouth Sub-Basin and surrounding basins have been subject to exploration activity due to their highly prospective hydrocarbon fields. The operational area and surrounding waters are predominantly used for petroleum exploration and development. The nearest FPSO is the Woodside Vincent Development (in production licence WA-28-L).

Four existing FPSO developments are currently operating in the region besides the NV FPSO:

+ Vincent Development (Maersk Ngujima-Yin FPSO) in WA-28-L, approximately 4 km south of the operational area;
+ Pyrenees Development (Pyrenees Venture FPSO) in WA-42-L, approximately 13 km south east of the operational area;

In addition to the FPSOs and in close proximity to the operational area the BHP operated Macedon Gas Development, including an offshore pipeline, is located approximately 20 km south east of the operational area (**Figure 3-16**).

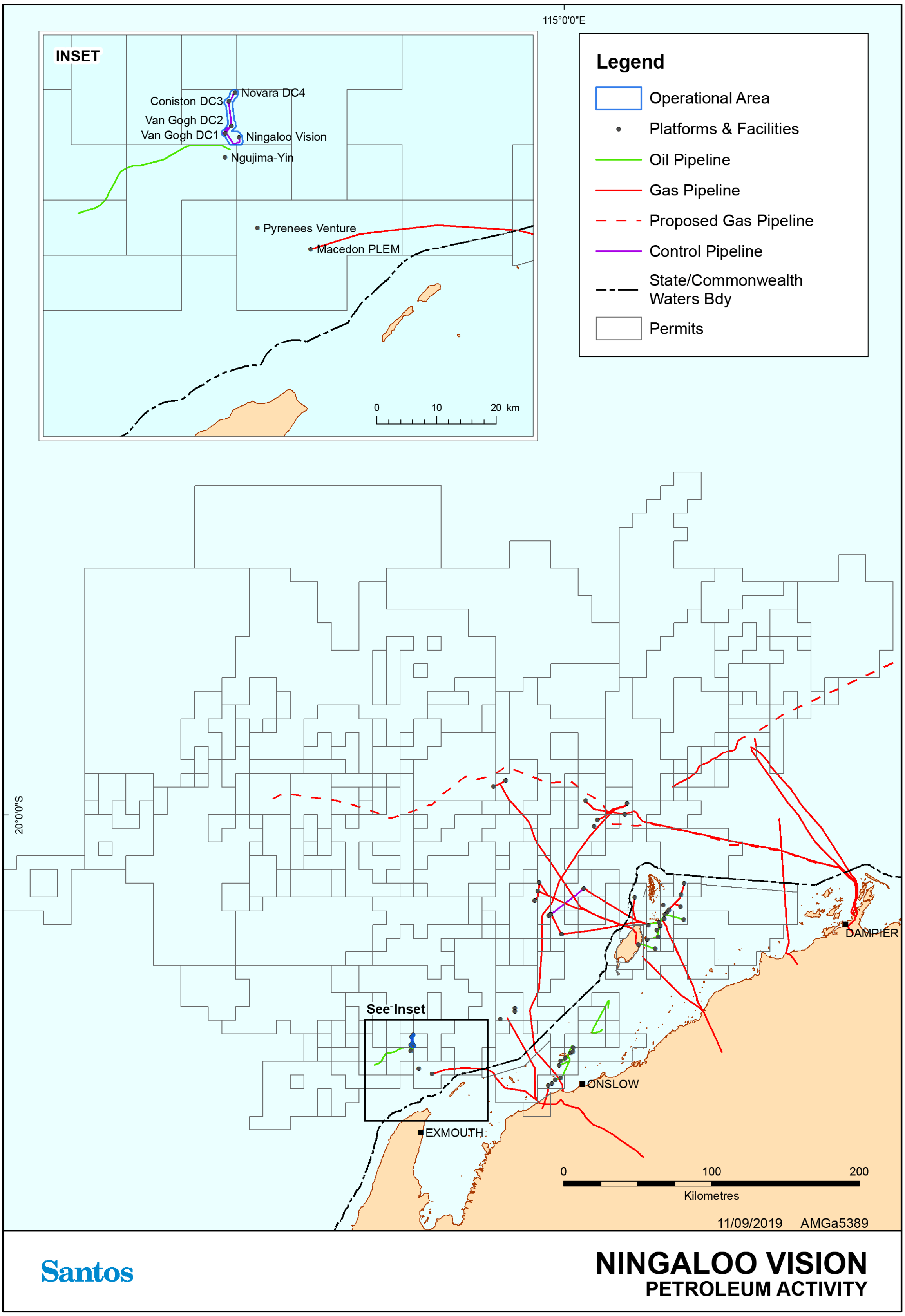

Figure 3-16: Existing Oil and Gas Activities Operating in the Vicinity of the NV Operations

3.2.5.3 Shipping

Under the *Commonwealth Navigation Act 1912*, all vessels operating in Australian waters are required to report their location on a daily basis to the Rescue Coordination Centre (RCC) in Canberra. This Australian Ship Reporting System (AUSREP) is an integral part of the Australian Maritime Search and Rescue system and is operated by Australian Maritime Safety Authority (AMSA) through the RCC.

There is a shipping route heading northeast approximately 40 km to the north west of the operational area; however, a relatively small number of vessels use this (AIS, 2020) (**Figure 3-17**).

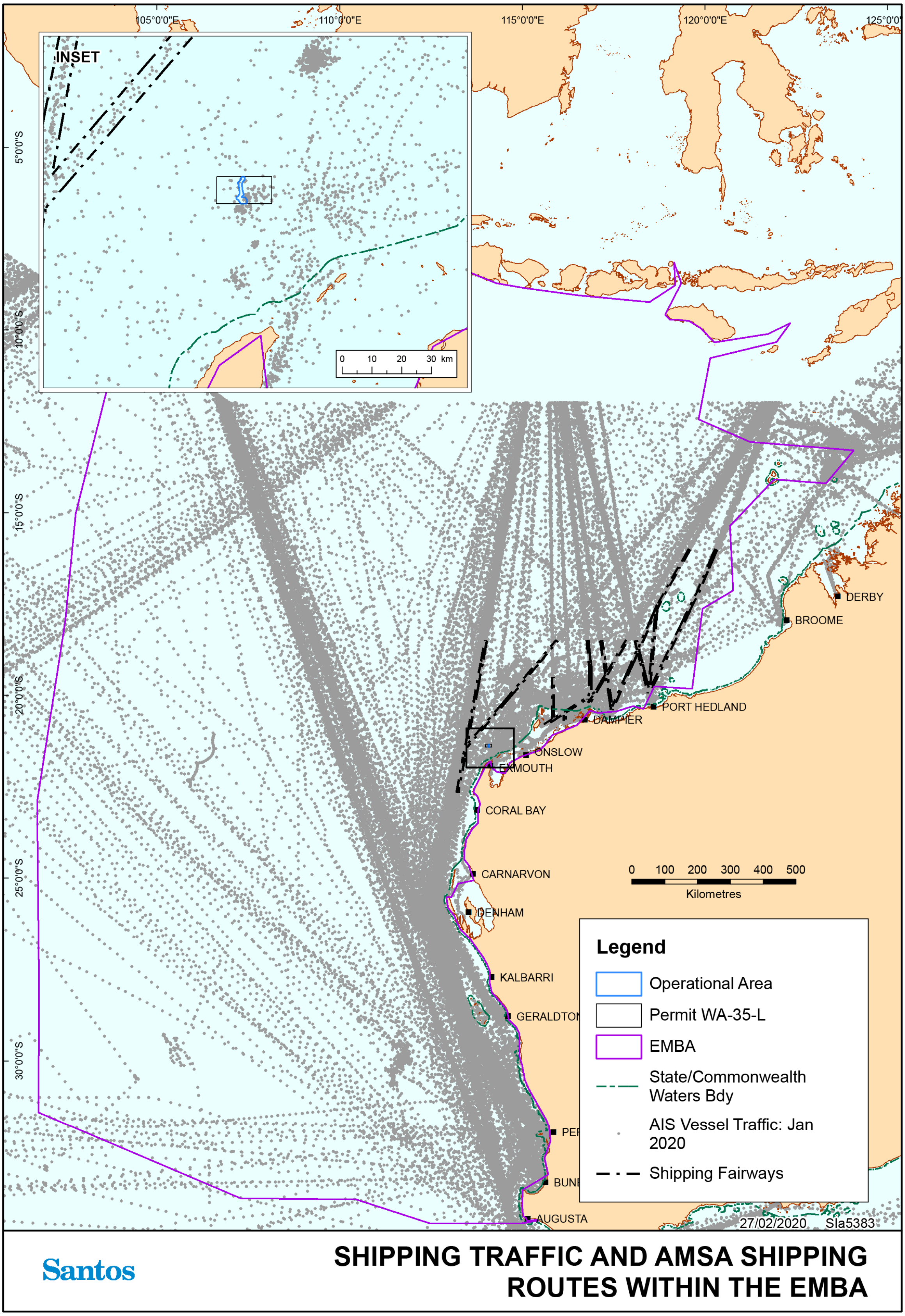

Figure 3-17: Shipping Traffic in the Vicinity of the NV Operations

3.2.6 Windows of sensitivity

Timing of peak activity for threatened and migratory species and other relevant, significant sensitivities is given in **Table 3-11**.

Table 3-11: Windows of Sensitivity in the Vicinity of the EMBA

Categories	Receptors (critical life cycle stages)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Physical environment and habitats	Non-coral benthic invertebrates												
	Coral (spawning periods)												
	Macroalgae	growing				shedding fronds				growing			
	Other benthic habitats												
Marine Fauna (incl. threatened/ migratory species)	**Fish/ Sharks and fisheries species**												
	Whale sharks			Aggregations at Ningaloo Coast									
	Fisheries species spawning/aggregation times [1]												
	Baldchin groper												
	Blacktip shark												
	Crystal crab												
	Goldband snapper												
	King George whiting												
	Pink snapper												
	Rankin cod												
	Red Emperor												
	Spangled Emperor												
	Sandbar shark												

Categories	Receptors (critical life cycle stages)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Spanish mackerel												
	Marine Mammals												
	Dugong (breeding)	breeding								breeding			
	Humpback whale (migration)						northern			southern			
	Blue whale (migration)					northern						southern	
	Marine Reptiles												
	Hawksbill turtle's resident adult and juveniles[2]	Widespread throughout NW Shelf waters, highest density of adults and juveniles over hard bottom habitat (coral reef, rocky reef, pipelines etc.)											
	Hawksbill turtle (mating aggregations[2])												
	Hawksbill turtle (nesting and internesting[2])												
	Hawksbill turtle (hatching[1])												
	Flatback turtles (resident adult and juveniles[2])	Widespread throughout NW Shelf waters, increased density over soft bottom habitat 10 – 60m deep, post hatchling age classes and juveniles spread across shelf waters											
	Flatback turtle (mating aggregations[2])												
	Flatback turtle (nesting and internesting[2])												
	Flatback turtle (hatching[2])												
	Flatback turtle (nesting[2])												

Categories	Receptors (critical life cycle stages)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Green turtles (resident adult and juveniles[2])	Widespread throughout the NW Shelf waters, highest density associated with seagrass beds and macro algae communities, high density juveniles in shallow waters off beaches, amongst mangroves and in creeks											
	Green turtle (mating aggregations[2])												
	Green turtle nesting and internesting[2])												
	Green turtle (hatching[2])												
	Loggerhead turtles (resident adult and juveniles[2])	Widespread throughout the NW Shelf waters, increased density associated with soft bottom habitat supporting their bivalve food source, juveniles associated with nearshore reef habitat											
	Loggerhead turtle (mating aggregations[2])												
	Loggerhead turtle (nesting and internesting[2])												
	Loggerhead turtle (hatching[2])												
	Olive Ridley turtle (nesting)												
	Leatherback turtles	Can occur at low density across the NWS year round											
	Short-nosed seasnake	Can occur at low density across the NWS year round											
	Seabirds												
	Terns, shearwaters, petrels (nesting)												

Categories	Receptors (critical life cycle stages)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Commercial Managed Fisheries												
	Oil and gas												
	Shipping												
	Tourism/ recreational	None applicable											

KEY / NOTES			
		Peak activity, presence reliable and predictable	[1] Information provided from Department of Fisheries consultation
		Lower level of abundance/activity/presence	[2] Information provided by K. Pendoley
		Very low activity/ presence	
		Activity can occur throughout year	
		Proposed timing of activity	

4 Stakeholder Consultation

OPGGS(E)R 2009 Requirements
Regulation 9AB
If the Regulator's provisional decision under regulation 9AA is that the environment plan includes material apparently addressing all the provisions of Division 2.3 (Contents of an environment plan), the Regulator must publish on the Regulator's website as soon as practicable: (a) the plan with the sensitive information part removed; and (b) the name of the titleholder who submitted the plan; and (c) a description of the activity or stage of the activity to which the plan relates; and (d) the location of the activity; and (e) a link or other reference to the place where the accepted offshore project proposal (if any) is published; and (f) details of the titleholder's nominated liaison person for the activity. Note: If the plan is a seismic or exploratory drilling environment plan, the Regulator must also publish an invitation for public comment on the plan: see regulation 11B.
Regulation 16
16 The environment plan must contain the following: (b) a report on all consultations under regulation 11 A of any relevant person by the titleholder, that contains: (i) a summary of each response made by a relevant person; and (ii) an assessment of the merits of any objection or claim about the adverse impact of each activity to which the environment plan relates; and (iii) a statement of the titleholder's response, or proposed response, if any, to each objection or claim; and (iv) a copy of the full text of any response by a relevant person.

4.1 Summary

The NV Operation is located in the Exmouth Basin in Commonwealth waters offshore NorthWest Australia. The nearest mainland coast is 50 km to the south, with North Muiron Island situated about 30 km in a south-easterly direction from the operation.

The NV Operation comprises three subsea oil field developments serviced by a single Floating Production, Storage and Offloading vessel (FPSO), the Ningaloo Vision. The Van Gogh oil field development commenced production in 2010 and the nearby Coniston and Novara oil field developments were tied back to the Van Gogh subsea infrastructure in 2015 and 2016 respectively. The Van Gogh Infill Drilling Program was also completed in 2018.

Santos has a long operating history with this facility and is familiar with local community stakeholders and other users of the marine environment in the region. Stakeholders have been engaged regarding activities associated with this operation since its development.

Stakeholders (**Table 4.1**) were informed of activities covered in this EP revision via several channels of engagement commencing in February 2019, including:

+ Santos' *Quarterly Consultation Update* distributed to the company's wider stakeholder cohort;
+ Ningaloo Vision Operations Environment Plan Revision Consultation Package distributed to identified stakeholders in March 2019, May 2019, February 2020 and March 2020;

- Ningaloo Vision Operations Environment Plan Revision Consultation Information for Commercial Fishers distributed to identified fishing licence holders;
- Exmouth Community Reference Group meetings held in March, August and November 2019 and March 2020;
- One on one briefings with individuals and groups as required, and
- Santos' regular presence in Exmouth and attendance at community functions also supports communications with the wider community.

Based on Santos' experience with the existing facility, and from subsequent stakeholder feedback and regulator discussions, the primary stakeholder issues of concern for this activity are:

- Oil spill response management (addressed in **Section 6.8**); and
- Interaction with other marine users, specifically commercial fishers (addressed in **Section 6.5**).

Santos has considered all stakeholder responses and assessed the merits of all objections and claims about the potential impact of the activity. The process adopted to assess these claims is outlined in **Section 4.4**. A summary of Santos' response statements to the objections and claims is provided in **Table 4-2.**

Santos considers that consultation with relevant stakeholders has been adequate to inform the development of this EP. Notwithstanding this, Santos recognises the importance of ongoing stakeholder consultation and notification and these are described in **Table 8-4 and Section 8.10.**

4.2 Stakeholder Identification

Santos understands retaining a broad licence to operate depends on the development and maintenance of positive and constructive relationships with a comprehensive group of stakeholders in the community, government, non-government, other business sectors and other users of the marine environment. Fostering effective consultation between Santos and relevant stakeholders is an important part of this process.

Santos began the stakeholder identification process for this EP with a review of its stakeholder database, including stakeholders consulted for the current EP and other recent activities in the area, specifically the Van Gogh In-fill drilling program. The list of stakeholders was then reviewed and refined based on the defined Operational Area **(refer to Section 2.2)**, the EMBA (refer to **Section 3.1)** and the relevance of the stakeholder according to Regulation 11A of the OPGGS (E) Regulations and NOPSEMA Bulletin #2 *Clarifying statutory requirements and good practice consultation* (November, 2019). More specifically, stakeholders for this EP were identified through the following:

- Regular review of legislation applicable to petroleum and marine activities;
- Identification of marine user groups and interest groups active in the area (e.g., commercial fisheries, other oil and gas producers, merchant shipping, etc.);
- A review of Department of Primary Industries and Regional Development (DPIRD) Fish Cube data;
- A review of fishing licence holder contact details, from these identified fisheries, as provided by DPIRD;
- Utilisation of the WAFIC Oil and Gas consultation services to advise on relevant commercial fisheries and fishers, and to review and distribute fishery-specific consultation material;
- Discussions with identified stakeholders to identify other potentially impacted persons;
- Active participation in industry bodies and collaborations (e.g., APPEA, AMOSC, NERA); and
- Records from previous consultation activities in the area.

In addition, new stakeholders who visit Santos' external facing website may contact the company via contact details provided online, and information about Santos' activities in WA is published on the website for new stakeholders to review. The EP is also published in full on the NOPSEMA website upon submission, allowing stakeholders to review and comment.

Currently identified stakeholders and an assessment of their relevance under the OPGGS (E) Regulations for the purposes of consultation for this activity are listed in **Table 4-1**.

Table 4-1: Assessment of relevance of identified stakeholders for the activity

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Commonwealth government departments/agencies		
Australian Maritime Safety Authority (AMSA)	Considered relevant persons under Regulation 11A(1) (a)	AMSA is the statutory and control agency for maritime safety and vessel emergencies in Commonwealth Waters. AMSA is a relevant agency when proposed offshore activities may impact on the safe navigation of commercial shipping in Australian waters. The operational area is in commonwealth waters.
Department of Defence (DoD)	Considered relevant persons under Regulation 11A(1) (a)	DoD is a relevant agency where the proposed activity may impact operational requirements; encroach on known training areas and/or restricted airspace, or when nautical products or other maritime safety information is required to be updated. The operational area is in commonwealth waters.
Australian Fisheries Management Authority (AFMA)	Considered relevant persons under Regulation 11A(1) (a)	AFMA is responsible for managing Commonwealth fisheries and is a relevant agency where the activity has the potential to impact on fisheries resources in AFMA managed fisheries. The operational area intersects with commonwealth managed fisheries.
Department of Agriculture, Water and the Environment (DAWE) – Fisheries	Considered relevant persons under Regulation 11A(1) (a)	DAWE (fisheries) has primary policy responsibility for promoting the biological, economic and social sustainability of Australian fisheries. The Department is the relevant agency where the activity has the potential to negatively impact fishing operations and / or fishing habitats in Commonwealth waters. The operational area intersects with commonwealth managed fisheries.

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Department of Agriculture,Water and the Environment (DAWE) – Biosecurity (vessels, aircraft and personnel)	Considered relevant persons under Regulation 11A(1) (a)	DAWE (vessels and aircraft) has inspection and reporting requirements to ensure that all conveyances (vessels, installations and aircraft) arriving in Australian territory comply with international health regulations and that any biosecurity risk is managed. The department is the relevant agency where the titleholder's activity involves: + the movement of aircraft or vessels between Australia and offshore petroleum activities either inside or outside Australian territory + the exposure of an aircraft or vessel (which leaves Australian territory not subject to biosecurity control) to offshore petroleum activities.
Department of Agriculture, Water and the Environment (DAWE) - Environment	Considered relevant persons under Regulation 11A(1) (a)	The Department's role in administering the EPBC Act includes ensuring the objectives of the EPBC Act are met. Santos has two EPBC Approvals (2007/3213, 2011/5995) under the EPBC Act relevant to this EP.
Australian Marine Oil Spill Centre (AMOSC)	Considered relevant persons under Regulation 11A(1) (a)	AMOSC operates the Australian oil industry's major oil spill response facility.
State government departments/agencies		
Department of Transport (DoT)	Considered relevant persons under Regulation 11A(1) (b)	DoT is the control agency for marine pollution emergencies in State waters.
Department of Primary Industries and Regional Development (DPIRD)	Considered relevant persons under Regulation 11A(1) (b)	DPIRD is responsible for managed West Australian State fisheries. The operational area intersects with state managed fisheries.
Department of Biodiversity, Conservation and Attractions (DBCA)	Considered relevant persons under Regulation 11A(1) (b)	DBCA is a relevant State agency responsible for the management of State marine parks and reserves and protected marine fauna and flora. The operational area is adjacent to state marine reserves.

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Department of Mines, Industry Regulation and Safety (DMIRS)	Considered relevant persons under Regulation 11A(1) (c)	Department responsible for the management of offshore petroleum in the adjacent State waters.
Neighbouring operators / exploration companies		
Woodside	Considered relevant persons under Regulation 11A(1) (e)	Woodside is listed as the titleholder of an adjacent petroleum permit.
BHP	Considered relevant persons under Regulation 11A(1) (e)	BHP is listed as the titleholder of an adjacent petroleum permit.
Industry bodies		
Western Australian Fishing Industry Council (WAFIC)	Considered relevant persons under Regulation 11A(1) (e)	WAFIC is the peak industry body representing the interests of the WA commercial fishing, pearling and aquaculture sector. The operational area intersects with State-managed fisheries.
Commonwealth Fisheries Association (CFA)	Considered relevant persons under Regulation 11A(1) (e)	The CFA is a representative body for Commonwealth fisheries. The operational area intersects with several Commonwealth-managed fisheries. The CFA is also listed on the AFMA website as a contact for petroleum operators to use when consultation with fishing operators is required.
Marine Tourism WA (MTWA)	Considered relevant persons under Regulation 11A(1) (e)	MTWA represents the charter sector in WA. Charter fishing occurs in the region. MTWA is identified as being able to assist in reaching its membership if required.
Recfishwest	Considered relevant persons under Regulation 11A(1) (e)	Recfishwest is the peak body representing recreational fishers in WA. Recreational fishing occurs in the region. Recfishwest is identified as being able to assist in reaching its membership if required.

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	Considered relevant persons under Regulation 11A(1) (e)	ASBTIA represents the Australian SBT industry. ASBTIA is also listed on the AFMA website as a contact for petroleum operators to use when consultation with Commonwealth fishing operators is required. WAFIC advises there is no fishing for Southern Bluefin in Western Australia. However stakeholders are alert / concerned regarding any potential impacts to the migratory route. Consultation is not required with licence / quota holders, however consultation is required with the peak body.
Community/Exmouth		
Cape Conservation Group (CCG)	Considered relevant persons under Regulation 11A(1) (e)	Exmouth-based Non-government Organisation (NGO). Focused primarily on protecting and preserving the North West Cape, now and for future generations. Identified as relevant given the location of the operation in relation to marine conservation areas and biologically important areas for turtles, and humpback whale migration pathways. Santos consults with the CCG as part of informing good environmental management practices.
Ningaloo Coast World Heritage Advisory Committee (NCWHAC)	Considered relevant persons under Regulation 11A(1) (e)	The NCWHAC was established as a representative stakeholder group in 2013 by agreement between the Commonwealth and WA governments. One of its many roles is to represent the viewpoint of the local and broader community and circulate information on key matters relevant to the World Heritage area. Santos consults with the NCWHAC as part of informing good environmental management practices.
Shire of Exmouth	Considered relevant persons under Regulation 11A(1) (e)	Exmouth is the nearest community to Santos' Ningaloo Vision Operations. The Exmouth Shire is the local government body for the region. Santos consults with the local Shire as part of informing good environmental management practices.
North West Cape Exmouth Aboriginal Corporation	Considered relevant persons under Regulation 11A(1) (e)	The corporation is identified as a potentially relevant stakeholder for this EP. Santos consults with the Corporation as part of informing good environmental management practices. .

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Exmouth Volunteer Marine Rescue Group (EVMRG)	Considered relevant persons under Regulation 11A(1) (e)	The EVMRG is identified as a potentially relevant stakeholder for this EP given its activities in the region.
Exmouth Game Fishing Club (EGFC)	Considered relevant persons under Regulation 11A(1) (e)	The EGFC was identified as a potentially relevant stakeholder for this EP. Recreational fishing may occur in the area of the NV operations. EGFC is identified as being able to assist in reaching its membership if required.
DBCA (Exmouth regional branch)	Considered relevant persons under Regulation 11A(1) (e)	DBCA is a relevant State agency responsible for the management of State marine parks and reserves and protected marine fauna and flora. The operational area is adjacent to state marine reserves.
DoT (Exmouth regional branch)	Considered relevant persons under Regulation 11A(1) (e)	DoT is the control agency for marine pollution emergencies in State waters.
Exmouth Chamber of Commerce (CCI)	Considered relevant persons under Regulation 11A(1) (e)	The Exmouth CCI is a member driven organisation providing information, professional services and support for businesses in the local Exmouth area. Santos consults with the CCI as part of informing good environmental management practices.
Gunn Marine Services	Considered relevant persons under Regulation 11A(1) (e)	Santos consults with this stakeholder as part of informing good environmental management practices.
Exmouth Freight and Logistics	Considered relevant persons under Regulation 11A(1) (e)	Santos consults with this stakeholder as part of informing good environmental management practices.
Base Marine	Considered relevant persons under Regulation 11A(1) (e)	Santos consults with this stakeholder as part of informing good environmental management practices.

Stakeholder	Relevant to Activity	Relevance/ Reason for Engagement
Exmouth Tackle and Camping	Considered relevant persons under Regulation 11A(1) (e)	Santos consults with this stakeholder as part of informing good environmental management practices.
Exmouth Bus Charter	Considered relevant persons under Regulation 11A(1) (e)	Santos consults with this stakeholder as part of informing good environmental management practices.
Exmouth Community Reference Group (CRG)	Considered relevant persons under Regulation 11A(1) (e)	The Exmouth Community Reference Group is convened three times a year in Exmouth, in collaboration with neighbouring oil and gas operators. The membership of this group is diverse and currently includes about 50 community representatives. Santos consults with the CRG as part of informing good environmental management practices.
Commercial fisheries - state managed		
Pilbara Line Fishery	Considered relevant persons under Regulation 11A(1) (d)	The Ningaloo Vision Operational area intersects with the Pilbara Line Fishery. Exmouth is also the home port to some Pilbara Line fishers. There are nine licenses in this fishery held by seven licence holders. On advice from WAFIC, all licence holders in this fishery have been consulted.
Commercial Fisheries – commonwealth managed		
North West Slope Trawl	Considered relevant persons under Regulation 11A(1) (d)	The boundaries of this fishery overlap the operational area. On advice from WAFIC, Fishing takes place in water depths between 200 and 750 metres. The same licence holders in this fishery also hold the licences in the Western Deepwater Trawl (boundary very close by). Three fishers in this fishery have been consulted.
Southern Bluefin Tuna Fishery	Considered relevant persons under Regulation 11A(1) (d)	The boundaries of this fishery overlap the operational area. On advice from WAFIC, consultation required with ASBTIA, not individual licence holders.
Western Tuna and Billfish	Considered relevant persons under Regulation 11A(1) (d)	The boundaries of this fishery overlap the operational area. On advice from WAFIC, one fisher is potentially active near the operational area and should be consulted.

4.3 Stakeholder Consultation

The approach to stakeholder consultation for this EP follows the process adopted by Santos for all its EPs. Some modifications to this approach have been made based on feedback from WAFIC, commercial fishers and NOPSEMA. These include:

+ Providing more detailed information to commercial fishers, targeted to their fishery, in the initial consultation packs;
+ Engaging WAFIC to assist in the review and distribution (if required) of commercial fisher consultation material;
+ Refinements to the stakeholder identification process to clearly identify and maintain current lists of 'relevant' persons, and
+ Clearly documenting and tracking notification commitments to relevant persons.

Key stakeholders were contacted by phone or meeting prior to providing the Ningaloo Vision Operations Environment Plan Revision Stakeholder Consultation package to increase activity awareness and to encourage two-way communication. Stakeholders, wherever possible, were provided personal emails with information tailored to their functions, interests and activities, including outlining why they have been identified as a relevant stakeholder.

The consultation package contains details such as an activity summary, location map, coordinates, water depth, distance to key regional features and vessel exclusion zone details. This consultation package outlined potential risks and impacts together with a summary of proposed management control measures. Stakeholders were encouraged to provide feedback on the proposed activity.

Individual fishing licence holders, identified in consultation with WAFIC, were provided the Ningaloo Vision Operations Environment Plan Revision Stakeholder Consultation package and additional summary information by email.

Stakeholders were afforded at least four weeks to review consultation packs, although Santos accepted stakeholder feedback after this period.

4.4 Assessment of stakeholder objections and claims

A summary of the stakeholder consultation undertaken for this EP, including Santos' assessment of all stakeholder comments received, is outlined in Table 4-2. A sample of outgoing communications to stakeholders, consultation packs and an example of a quarterly consultation update is provided is contained in **Appendix E**.

Full transcripts between Santos and stakeholders are provided in the Ningaloo Vision Operations Environment Plan Revision Sensitive Stakeholder Information Report as a confidential submission to NOPSEMA.

Santos adopted the following process to address objections and claims received during the consultation process:

+ Santos acknowledged receipt of all comments made by stakeholders;
+ Santos assessed the merits of all objections and claims made by stakeholders. This included assessing all reasonably available options for resolving or mitigating the degree to which a stakeholder's functions, interests or activities may be affected. Control measures were proposed where reasonably practicable;
+ Santos responded to all stakeholder objections and claims, and advised the stakeholder how each of their issues would be addressed in the EP;
+ Santos invited the stakeholder to provide additional feedback and comment; and

+ As soon as possible, or on publication of the EP on the NOPSEMA website, Santos advised all stakeholders who had made an objection or claim, where their specific objection or claim was represented in the EP.

A similar process was applied to information provided and requests made by stakeholders not deemed to be an objection or claim.

Santos recognises the importance of ensuring a high degree of transparency in how a titleholder manages ongoing stakeholder consultation during the life of an activity. As such, should additional stakeholder comments be received to those described in **Table 4-2** then Santos will assess the comments using the above process, ensuring the EP is updated to document the assessment of any additional objections or claims.

In relation to stakeholder consultation Santos is of the opinion that Regulation 10A of the OPGGS(E) Regulations has been met.

Table 4-2: Consultation summary for activity

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><th colspan="3">Commonwealth departments/agencies</th></tr>
<tr><td rowspan="3">Australian Maritime Safety Authority (AMSA)</td><td colspan="2">AMSA was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 27 May 2019 and a revised consultation package via email on 13 February 2020.
AMSA receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
No comments received to date from AMSA.
Santos has addressed navigational requirements in Table 8-2.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No response required.</td><td>No assessment required.</td></tr>
<tr><td rowspan="2">Australian Marine Oil Spill Centre (AMOSC)</td><td colspan="2">AMOSC was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 27 May 2019 and a revised consultation package via email on 13 February 2020.
AMOSC receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
No comments received to date from AMOSC.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
</table>

	No assessment required.	No response required.
Department of Defence (Defence)	Defence was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. Defence responded on 18 February 2020 advising: + Defence has no objections to the proposed activities. **[INFORMATION 001]** + The operational area is within the North Western Exercise Area (NWXA) and military restricted airspace (R853A). In order to ensure Santos activities do not conflict with Defence training, Defence requests a minimum of five weeks notification prior to the commencement of activities**. [REQUEST 001]** + Please ensure continued liaison with the Australian Hydrographic Service (AHS), ensure that the AHS is notified three weeks prior to the actual commencement of activities. This information is critical to maritime safety and reduces negative impacts on other maritime users **[REQUEST 002]**. Santos responded to Defence on 24 March 2020 and addressed each of the matters raised in their correspondence of 18 February 2020 (refer assessment of stakeholder objections and claims). Defence receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	INFORMATION 001 Santos notes Defence has no objections to the proposed activities.	Santos responded to Defence confirming this information would be taken into consideration in the drafting of the EP
	REQUEST 001. In consultation with Defence, Santos advised that this is an existing and ongoing operational activity and as such, no commencement notification could be provided.	Santos responded to Defence and agreed to notify Defence prior to the NV FPSO leaving and returning to the operational area, for the planned 2020 shipyard campaign (Refer to Table 8-4)

	REQUEST 002 In consultation with Defence, Santos confirmed continued liaison with the Australian Hydrographic Service when project vessels are in the operational area for specific project/campaign type activities.	Santos agreed to continue liaison with the Australian Hydrographic Service when project vessels are in the operational area for specific project/campaign type activities (Refer to **Table** 8-4)
Australian Fisheries Management Authority (AFMA)	AFMA was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. Santos emailed AFMA on 11 December 2019 inviting the Department to provide comment on or discuss Santos' updated Scientific Monitoring Plan and baseline data review and/or receive copies of these for information. AFMA receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date from AFMA. AFMA has previously advised it is important to consult with all fishers who have entitlements to fish within the proposed activity area. This can be done through the relevant fishing industry associations or directly with fishers who hold entitlements in the area. Santos has consulted directly with relevant fishers and fishing industry associations as outlined in Table 4.2. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Department of Agriculture, Water and the Environment – Biosecurity (vessels, aircraft and personnel)	The Department (Biosecurity) was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. The department responded on 21 February 2020 providing advice on the Australian Government's biosecurity requirements. In summary, the department advised: + It is our understanding that your intended operating practices may expose domestic conveyances (support vessels and aircraft) to interactions with the survey vessel which may pose an unacceptable level of biosecurity risk. Where domestic conveyances become exposed through interactions with persons, goods or conveyances outside Australian territory they automatically become subject to biosecurity control upon their return. If the department concludes that the level of biosecurity risk associated with the survey vessel is low, within the meaning of the Biosecurity (Exposed Conveyances – Exceptions	

<table>
<tr>
<td rowspan="3"></td>
<td colspan="2">from Biosecurity Control) Determination 2016 (the Determination), an exposed conveyance may be eligible for an exception from biosecurity control. [CLAIM 001]
+ For exposed conveyances to be assessed as low risk, the offshore installation must demonstrate that it meets the requirements set out in the Determination. To have risk status assessed, offshore installation projects must apply to the department at least one month prior to project commencement. The department will work with installation representatives to assess the biosecurity risk of the installation and associated support conveyances (vessels and aircraft). Note: To be eligible, an exposed conveyance must meet all circumstances as outlined in section 6 of the Determination. [INFORMATION 001]
+ Please review the department’s Offshore Installations webpage and associated Offshore Installations Biosecurity Guide which provides specific biosecurity information for operators of offshore installations and notify the department where your project which may have conveyance interactions with Australian territory, or to discuss a biosecurity assessment [REQUEST 001]
+ Please also review Australian ballast water and biofouling requirements and pre-arrival reporting using MARS. [REQUEST 002]
Santos responded to the Department on 30 March 2020 and addressed each of the matters raised in their correspondence of 21 February 2020 (refer assessment of stakeholder objections and claims).
It is also noted that Santos met with the Department on 26 August 2019 regarding biosecurity of offshore platforms. The focus largely related to whether Santos had retained a “low risk” quarantine/biosecurity status for its offshore platforms and FPSO, and how Santos will manage the risk for vessels going from port out to these sites and back again. Santos has confirmed a current low risk status of its offshore installations and is continuing to work with the Department to determine subsequent risk management arrangements.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td>
</tr>
<tr>
<td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td>
<td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td>
</tr>
<tr>
<td>[CLAIM 001] Santos has addressed biosecurity requirements in Table 8.2, CM-50.</td>
<td>Santos has addressed the Department’s Biosecurity requirements through implementation of Santos’ Invasive Marine Species Management Plan (EA-00-RI-10172) as provided for in Table 8-2 (control measure CM-50).</td>
</tr>
</table>

	INFORMATION 001] Santos Notes DAWR comments.	No response required.
	[REQUEST 001] Santos acknowledges the biosecurity requirements outlined by DAWR and will continue to liaise with the Department for clarity to ensure compliance with their requirements.	Santos responded to DAWR seeking further discussion on the matters.
	[REQUEST 002] Santos has addressed the Department's ballast water and antifouling requirements through implementation of Santos' *Invasive Marine Species Management Plan* (EA-00-RI-10172) as provided for in **Table 8-2** (control measure CM-50).	Santos responded to DAWR and confirmed their requirements would be considered in the revision of the EP.
Department of Agriculture, and the Environment – Fisheries	The Department (Fisheries) was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. Santos emailed the Department on 11 December 2019 inviting the Department to provide comment on or discuss Santos' updated Scientific Monitoring Plan and baseline data review and/or receive copies of these for information. No comments received to date. Santos has assessed the impact to fish and commercial fisheries in **Section 6.5** Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Department of Agriculture, Water and the Environment – Environment	Santos engaged with the Department (Post Approvals Section) on 16 June 2020 to discuss the conditions of the Van Gogh Approval, specifically condition 6, and the expiry date. Santos and the Department discussed Santos' revised EP in a video conference on 13 July 2020.	

	In a follow-up email on 13 July 2020, the Department provided Santos with details of the information to accompany an application to extend the period of any approval, and the Department's guidance on new or increased impact in relation to revised management plans. Santos acknowledged the Department's guidance in an email of 14 July 2020. Following on from the 14th of July 2020 email, Santos looked further into the Van Gogh Approval 2007/3213, the regulatory streamlining process (as part of Streamlining environmental regulation of petroleum activities in Commonwealth waters) and the application of relevant conditions. Santos identified an error in that the Consolidated Approval Notice dated 18 September 2015 ("**Consolidated Notice**") contains an error in Condition 14. and that the Variation Notice is the legally binding version of the changes introduced to EPBC 2007/3213. Furthermore, Santos concluded that its only obligation is to submit the NV EP revision to NOPSEMA for approval under the OPGGS Environmental Regulations; and Santos is no longer required to submit NV EP revisions to DAWE for assessment or approval. Santos engaged with DAWE (Post Approvals Section) via a video conference on 19th August 2020 to outline the above findings, and followed up with an email to DAWE to clarify and close out the matter of Condition 6. DAWE responded by email on the 19th August 2020 thanking Santos for the clarification to set the matter out and noted that DAWE will correct the Consolidated Notice. **Appendix B** contains detail on the EPBC Approval 2007/3213 matters. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.

Santos

State Government Departments	
Department of Transport (DoT)	DoT was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019. DoT responded to the consultation package via email on 4 June 2019 advising: + If there are any changes to the corresponding Oil Spill Contingency Plan/Oil Pollution Emergency Plan, or change to spill risk, please ensure that the Department of Transport is consulted in accordance with the requirements outlined in the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (September 2018). **[REQUEST 001]** Santos responded to DoT on 5 June 2019 confirming their comments would be taken into account in the revision of the EP and OPEP. DoT was provided the revised *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 13 February 2020. DoT responded on 24 February 2020 advising: + No further comments beyond that which has already been provided **[INFORMATION 001]**. DoT was provided a copy of the Ningaloo Vision Operations OPEP, (as submitted with the EP), on 14 May 2020. DoT responded on 17 June 2020: + In Table 6-3 of the OPEP it suggests that there is now a 100% chance of a shoreline impact on the Ningaloo Coast from a subsea well leak (worst-case scenario). Please provide some clarity on the interpretation of these results as the likelihood on receptors in Revision 3.1 appeared to be significantly lower? **[REQUEST 002]** + Please confirm that the 24 hour contact number for Department of Transport oil spill response is detailed in the Santos Incident Response Telephone Directory? **[REQUEST 003]** + Section 5.2.3 details that DoT's control rests primarily for State waters activities – please note that DoT only has jurisdiction in State waters. **[INFORMATION 002]** + Section 5.5.2 refers to the northwest Regional Response Team – please note that DoT does not have teams of this name **[INFORMATION 003]** Santos responded to DoT on 18 June 2020 and addressed each of the matters raised in their correspondence of 17 June 2020 (refer assessment of stakeholder objections and claims). Santos and DoT discussed the data and modelling results in the OPEP by telephone on 25 June 2020. DoT responded on 25 June 2020 and advised:

	+ DoT was happy for Santos to incorporate the agreed changes (as per the email chain) in the next revision of the OPEP **[REQUEST 004]** + Please provide DoT a final accepted copy of the OPEP when available **[REQUEST 005].** Santos responded to DoT on 25 June 2020 and confirmed the department would receive the final accepted OPEP when available. DoT receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	[REQUEST 001] Santos will provide DoT information requested as per the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (September 2018), upon submission of the EP.	Santos responded to DoT and confirmed their requirements would be considered in the revision of the EP.
	[INFORMATION 001] Santos notes DoT comments.	No response required.
	[REQUEST 002] DoT requested clarification of the results shown in Table 6-3 of the OPEP compared to an earlier revision of the OPEP.	Santos responded to DoT and explained Table 6-3 of the OPEP (Revision 4) presents shoreline loading results but no surface oil (floating oil) contact results, whereas Table 3-6 of the OPEP Rev 3.1 presents surface oil contact results but no accumulation results. This accounts for the discrepancy in probabilities between these tables. Santos acknowledged Table 6-3 was confusing that both floating oil and accumulated oil results should be presented in the OPEP. This will be

		rectified in the next revision of the OPEP (Revision 5).
	[REQUEST 003] Can you please confirm that the 24 hour contact number for Department of Transport oil spill response is detailed in the Santos Incident Response Telephone Directory?	Santos responded to DoT and confirmed the MEER Duty Officer (24h) number is listed in the Incident Response Telephone Directory.
	[INFORMATION 002] Section 5.2.3 details that DoT's control rests primarily for State waters activities – please note that DoT only has jurisdiction in State waters.	Santos responded to DoT and acknowledged that DoT has jurisdiction for State waters marine pollution response however as per Section 6.5.4 of the IGN, DoT may be the Lead IMT "for some functions that apply across the entire incident response". An example of this specified in the IGN is Wildlife Operations. Appendix 2 of the IGN specifies that in a cross jurisdictional response DoT would be the Lead IMT controlling Wildlife Operations "including wildlife in Commonwealth waters"
	[INFORMATION 003] Section 5.5.2 refers to the northwest Regional Response Team – please note that DoT does not have teams of this name	Santos responded to DoT and confirmed reference to a Regional Response Team would be removed from Section 5.5.2, leaving reference to State Response Team only.
	[REQUEST 004] DoT agreed to Santos incorporating the agreed changes in the next revision of the OPEP.	The agreed changes have been incorporated in the revised OPEP as outlined in the email chain and as summarised in this Table.
	[REQUEST 005] Santos to provide DoT a final accepted copy of the OPEP when available	Santos responded to DoT and confirmed DOT would receive a copy of the accepted OPEP once available.
	DPIRD was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 23 May 2019.	

Department of Primary Industries & Regional Development (DPIRD)	DPIRD responded to the consultation package via email on 20 June 2019:
	+ Requesting that Santos consult the following representative bodies as appropriate to the proposed activities **[REQUEST 001]**:
	  + Western Australian Fishing Industry Council (WAFIC);
	  + Pearl Producers Association of WA;
	  + Recfishwest; and
	  + Relevant Traditional Owner groups.
	+ The Department also requested that individual commercial fishers and charter operators who fish in the affected area are consulted. **[REQUEST 002]**
	+ The Department provided guidance on where to access information on the relevant fisheries and fish stock in the proposed area. **[INFORMATION 001]**
	+ In the event of an oil spill or discharge of any other pollutant into the environment, the Department requested that its spill response officer is contacted within 24 hours of Santos reporting the incident to the appropriate authority. **[REQUEST 003]**
	+ When developing the Oil Pollution Emergency Plan (OPEP), the Department requested that Santos collects and maintains marine baseline data to compare against any post-spill monitoring to determine the nature and extent of any impacts. This data should be made available to the Department upon request. **[REQUEST 004]**
	+ The Department expects that Santos in its EP has considered and incorporated the recommendations published by NOPSEMA on Produced Formation Water regarding the Ningaloo Vision Operations. **[REQUEST 005]**
	+ Spawning grounds and nursery areas for key fish species are particularly vulnerable to the impacts of spills or sudden changes to the marine environment such as water quality, temperature. The Department therefore requested that specific strategies are developed in the EP and/or OPEP to mitigate these risks. DPIRD provided updated finfish spawning information, based on the most current science from relevant scientists. **[REQUEST 006]**
	Santos responded to DIPRD on 4 July 2019 and addressed each of the matters raised in their correspondence of 20 June 2019 (refer assessment of stakeholder objections and claims). Santos offered to provide further information on the EP, OPEP or Oil Spill Scientific Monitoring Plan.
	Santos emailed DPIRD on 11 December 2019 inviting the Department to provide comment on or discuss Santos' updated Scientific Monitoring Plan and baseline data review and/or receive copies of these for information.
	DPIRD was provided a copy of the revised *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 13 February 2020 and invited to provide any addition comments.
	No further comments were received from DPIRD.

	DPIRD receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	[REQUEST 001] Santos has consulted with the relevant peak fishery bodies, charter operators and Traditional Owner groups as identified in **Table 4-1**.	Santos responded to DPIRD acknowledging their request and the groups consulted.
	[REQUEST 002] Santos has consulted individual commercial fishers who fish near the operational area. Santos utilised the WAFIC Oil and Gas consultation services and DPIRD data to identify relevant commercial fisheries and fishers for consultation.	Santos responded to DPIRD acknowledging their request and the action being taken.
	[INFORMATION 001] Santos has assessed the impact to fish and commercial fisheries in **Section 6.5**	Santos responded to DPIRD acknowledging the information provided and the action being taken.
	[REQUEST 003] Santos has included notification details of the DPIRD spill response officer in the corresponding Oil Pollution Emergency Plans (OPEPs) for the EP.	Santos responded to DPIRD acknowledging their request and the action taken.
	[REQUEST 004] The OPEPs developed for these activities contain spill response strategies that have been developed to mitigate impacts to key environmental sensitivities which include marine and coastal habitats, fauna and socio-economic activities. The OPEPs detail the net environmental benefit analysis process that would be followed to verify that strategies and tactics are selected that provide the greatest net benefit to the environment, this considers the spatial and temporal sensitivity of resources at risk, which would include fish habitats, fisheries and fishing activities, where relevant.	Santos responded to DPIRD acknowledging their request and the action taken.
	[REQUEST 005] The OPEPs detail Santos' oil spill scientific monitoring arrangements that would be implemented in the event of a spill. The scientific monitoring plans provides details of monitoring that would be	Santos responded to DPIRD acknowledging their request and the action taken.

Santos

	implemented across all key environmental receptors including arrangements for monitoring fish, fisheries and aquaculture. Santos has identified relevant baseline data for its scientific monitoring plans and outlines the process for collecting further data for impact assessment.	
	[REQUEST 006] Santos has considered DPIRD comments and included an assessment within **Section 6.7**	Santos responded to DPIRD acknowledging their request and the action taken.
Department of Biodiversity and Conservation Attractions (DBCA)	The DBCA was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. Santos emailed DBCA on 4 July 2019 advising it would shortly be submitting its Oil Pollution Emergency Plans to NOPSEMA for the Ningaloo Vision Operations EP as part of NOPSEMA's 5-year revision requirements. This will also include the Scientific Monitoring Arrangements Santos would be implementing to monitor impacts from a spill. Santos invited DBCA to receive a copy of these plans for information or comment. Santos emailed DBCA on 11 December 2019 inviting the Department to provide comment on or discuss Santos' updated Scientific Monitoring Plan and baseline data review and/or receive copies of these for information. DBCA contacted Santos by telephone on 10 February 2020 and 11 February 2020 to discuss Santos' email of 11 December 2019 relating to Santos' Offshore Oil Sill Scientific Monitoring Plan. Santos phoned DBCA to discuss the correspondence and emailed a formal response to DBCA on 20 February 2020 attaching, as requested by DBCA the current version of the oil spill scientific monitoring plan and most recent baseline data review. DBCA responded to Santos' *Ningaloo Vision Operations Environment Plan Revision Consultation Package* on 14 February 2020 and advised: + There are a number of ecologically important areas including marine parks and island conservation reserves located in the vicinity of the proposed operations, including the Ningaloo Marine Park and Muiron Islands Marine Management Area and Nature Reserve. Based on the information you have provided it appears that there is potential for these areas to be affected by Santos' operations if there is a substantial hydrocarbon release and subject to weather or other environmental conditions. Given the ecological importance of areas potentially affected by a hydrocarbon release from Santos' operations, it is considered important that the baseline values and state of the potentially affected environment are appropriately understood and documented prior to any operations commencing that pose a significant risk of impacting these areas. DBCA would like to have confidence that Santos has appropriate baseline survey data on the important ecological values of these areas and any current contamination if present within the area of potential impact of spills (as identified through Santos' modelling). Following desktop review and risk assessment, Santos should also collect appropriate baseline abundance and distribution data for any threatened and specially protected marine fauna species in the area of potential impact, including information on the key habitats these species use for activities like foraging, breeding and aggregating. If baseline information is not available, Santos should thoroughly assess what baseline information is required commensurate with the level of risk	

	associated with the proposed activities, and identify suitable sources/methods to attain that information such that Santos can ensure that any impacts on ecological values and recovery of these values can be monitored and remediated. DBCA undertakes monitoring in marine parks and reserves and publishes monitoring reports which are available on the department's website. However, Santos should be aware that this monitoring is targeted to inform DBCA's values and objectives relating to marine park management and is not necessarily suitable to provide all baseline information required for oil spill risk assessment and management planning. DBCA encourages Santos to ensure it attains all information required to implement a Before-After, Control-Impact (BACI) framework in planning its management response. This may include independently monitoring and collecting data where required or identifying other data sources**. [REQUEST 001**] + In developing its Environmental Plan, DBCA also recommends that Santos refer to the Commonwealth Department of Agriculture, Water and the Environment's National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds as a best-practice industry standard for managing potential impacts of light pollution on marine fauna (https://www.environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife). **[REQUEST 002]** + In the event of a hydrocarbon release, it is requested that Santos notify DBCA's Pilbara regional office as soon as practicable. Note however, that DBCA will not implement an oiled wildlife management response on behalf of a petroleum operator except as part of a whole of government response mandated by regulatory decision makers, and any advice or assistance from DBCA, at any scale, will occur on a full cost recovery basis. Santos should also commit to the monitoring and clean-up of any DBCA interests affected by an oil spill in consultation with DBCA. **[REQUEST 003]** + Santos should refer to the Department of Transport's (DoT) web content regarding marine pollution (https://www.transport.wa.gov.au/imarine/marine-pollution.asp), and the Offshore Petroleum Industry Guidance Note of September 2018 titled Marine *Oil Pollution: Response and Consultation Arrangements*. These documents provide information on the Western Australian emergency management arrangements for marine oil pollution incidents in State waters, petroleum titleholders' obligations under those arrangements, and the DoT's expectations as the jurisdictional authority for such incidences. **[REQUEST 004]** Santos responded to DBCA on 16 March 2020 and addressed each of the matters raised in their correspondence of 14 February 2020 (refer assessment of stakeholder objections and claims). DBCA receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.

	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims,**

		information and requests (OPGGS(E) Regulation 16 (b)(iii))
	[REQUEST 001] Santos has operated the Ningaloo Vision FPSO in this region since 2009/2010. In recognition of the business operating risks and environmental sensitives of this region, Santos has dedicated resources to manage environmental monitoring programs and oil spill response preparedness and response planning. The Ningaloo Vision Oil Pollution Emergency Plan (OPEP) will contain the following information: + Details of Santos' Oil Spill Scientific Monitoring Plan including relevant subplans for the monitoring key values and sensitivities in the region (including those of Ningaloo Marine Park and Muiron Islands Marine Management Area and Nature Reserve). These subplans include Marine Water and Sediment Quality, Shorelines and Coastal Habitats, Benthic Habitats, Seabirds and Shorebirds, Marine Megafauna and Marine Reptiles and detail initiation criteria, sampling methodologies, study design and use of baseline data. Santos' Oil Spill Scientific Monitoring Plan (previously provided) outlines the use of a BACI approach with pre-impact baseline data, as well as other study design approaches. The Oil Spill Scientific Monitoring Plan is reviewed annually to ensure the plan is fit for purpose and relevant to all key sensitivities that could be impacted from an oil spill. + The revised OPEP will continue to contain detail of Santos' standby services arrangements with scientific monitoring providers to enable rapid baseline monitoring where required. The readiness and implementation arrangements with these providers are outlined in a standby and response services manual which is reviewed annually and tested regularly. + Santos periodically reviews and documents the status, availability and suitability of existing baseline data sources related to high biodiversity value receptors potentially contacted by an oil spill from its operations. This baseline review (previously provided) includes data made available by industry and government through the Industry-Government Environmental Metadata (I-GEM) Project. Santos has determined	Santos responded to DBCA acknowledging their request and the action taken.

<table>
<tr><td></td><td>areas/values that should be sampled as a priority based on the availability and quality of baseline data.
Based on the arrangements and planning detailed above, Santos is of the view that any impacts on ecological values and recovery of these values can be determined and monitored over the long term.
Santos looks to continuously improve its oil spill scientific monitoring arrangements and welcomes any feedback on the Scientific Monitoring Plan and baseline data review previously provided to DBCA (11 December 2019).
Santos has provided DBCA a copy of the current version of the oil spill scientific monitoring plan and most recent baseline data review.</td><td></td></tr>
<tr><td></td><td>[REQUEST 002] Santos will consider the Commonwealth Department of the Environment and Energy’s Draft National Light Pollution Guidelines for Wildlife as a best-practice industry standard for managing potential impacts of light pollution on marine fauna. Such lighting management controls for marine fauna will need to be balanced against marine navigation and operational safety requirements. Lighting impacts are considered in Section 6.2.</td><td>Santos responded to DBCA acknowledging their request and the action taken.</td></tr>
<tr><td></td><td>[REQUEST 003] Santos will continue to comply with DBCA’s oil spill reporting and consultation requirements.</td><td>Santos responded to DBCA acknowledging their request and the action taken.</td></tr>
<tr><td></td><td>[REQUEST 004] The revised Ningaloo Vision Oil Pollution Emergency Plan (OPEP) will continue to reflect Department of Transport’s (DOT) marine pollution response arrangements as per the September 2018 Offshore Petroleum Industry Guidance Note. Santos will consult with DOT as per the Industry Guidance Note.</td><td>Santos responded to DBCA acknowledging their request and the action taken.</td></tr>
<tr><td>Department of Mines, Industry Regulation and Safety (DMIRS)</td><td colspan="2">DMIRS was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 27 May 2019.
DMIRS responded on 27 June 2019 and advised:
+ In relation to the Ningaloo Vision Operations EP Revision update provided on 27 May 2019, no further information was required. [INFORMATION 001]
Santos responded to DMIRS on 4 July 2019 and acknowledged their feedback.
DMIRS was sent the revised Ningaloo Vision Operations Environment Plan Revision consultation package via email on 13 February 2020.
No further comments were received from DMIRS.</td></tr>
</table>

<table>
<tr><td rowspan="3"></td><td colspan="2">DMIRS receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>[INFORMATION 001] Santos notes DMIRS feedback.</td><td>Santos responded to DMIRS and acknowledged their feedback.</td></tr>
<tr><td colspan="3">Neighbouring operators</td></tr>
<tr><td rowspan="3">Woodside</td><td colspan="2">Woodside was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 27 May 2019 and a revised consultation package via email on 13 February 2020.
No comments received to date.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="2">BHP</td><td colspan="2">BHP was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 27 May 2019 and a revised consultation package via email on 13 February 2020.
No comments received to date.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims,</td></tr>
</table>

		information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Industry bodies		
Western Australian Fishing Industry Council (WAFIC)	WAFIC was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019. WAFIC responded to the consultation pack via email on 28 June 2019, commenting as follows: + This is a generic consultation package with zero reference to commercial fishing. Noting as per the regulations regarding "relevant potentially affected parties to an activity", by and large, the commercial fishing sector is the only stakeholder on the water who may be potentially (financially, functionally) impacted by offshore activities, therefore it is our expectation that consultation is bespoke for our industry. To read through a consultation update and the two words "commercial fishing" are not mentioned once is very frustrating. **[INFORMATION 001]** + Please advise which fisheries you liaised with (relevant parties) as part of this EP consultation. **[REQUEST 001].** + WAFIC acknowledge this is pre-existing infrastructure and activities, and a "business as usual" plan**. [INFORMATION 002**] + Understand it is located in a pre-existing 500 metre radius exclusion zone with a 2.5nm cautionary zone. Commercial fishers have had issues in the north-west re access to cautionary zones. It is essential that access rights of commercial fishers are protected. Is Santos's staff, contractors and sub-contractors all aware of the difference between exclusion zones and cautionary zones? Fishers understand the zero access criteria for O&G safety / exclusion zones however, for cautionary zones they are permitted to "*anchor, transit and or fish as long as it is safe to do so*". What is Santos's communications strategy to ensure this is fully understood by all staff, contractors and subcontractors etc to avoid any on-water misunderstandings and unnecessary impacts on commercial fishing activities / at sea mobility? **[REQUEST 002]** + Facility and subsea inspection, maintenance and repair activities. It is noted that this may result in additional vessels in the field. This has been an issue for commercial fishers issue in other areas in the north-west. What is the Santos's communication policy with all staff and vessel crew, contractors and sub-contractors regarding interacting and protecting the rights of active commercial fishers on the water? All support vessels must divert around active commercial fishing activity and remain clear of underwater fishing gear (even if not convenient to do so). All support vessels are to avoid any close and or disruptive engagement with any commercial fishing activity. All support vessels in the vicinity of a commercial fishing vessel to do their utmost not to create an ocean disturbance risking disruption to schooling fish, etc. **[REQUEST 003]** + Decommissioning and well abandonment and activities. Understand these activities are not included in the EP update. We look forward to working with Santos in the future when this site reaches the end of its life and proceeds down the decommissioning route. May we suggest, if possible, as an interim between end of life and decommissioning, if safe to do	

	so, if Santos could make note to consider removing the exclusion zone during this interim period should there be a delay between end of site life and finalisation of decommissioning. **[REQUEST 004]** + Table on page 3 under Interactions with other marine users. It would be greatly appreciated if the above point regarding interaction with commercial fishing activities etc is contained within this table acknowledging the need to also protect commercial fisher access, not just the safety zone for the platform. **[REQUEST 005]** + In addition, it is WAFIC's expectation that there is no recreational fishing from any Santos vessel, contractor's vessels and subcontractors etc vessels. Commercial fishers are not permitted (illegal) to recreationally fish whilst engaged in commercial fishing activity, based on impact on the (fish) resource and safety. It is the commercial fishing industry expectation that there is zero recreational fishing from any support or O&G commercial vessel. Can Santos please confirm that the *"No fishing from support/commercial vessels"* policy is abided by all at operator / proponent level and also strictly enforced and communicated with contractors and subcontractors? What is Santos's audit / compliance policy / process regarding recreational fishing on support/commercial vessels, for example, do you have a contractual arrangement which prohibits bringing any recreational fishing gear on to any vessels (operators, contractors and or subcontract vessels) etc? **[REQUEST 006]** Santos responded to WAFIC on 12 February 2020 and addressed each of the matters raised in their correspondence of 28 June 2019 (refer assessment of stakeholder objections and claims). WAFIC was provided the revised *Ningaloo Vision* Operations Environment Plan Revision consultation package via email on 16 March 2020. WAFIC acknowledged receipt of the revised consultation pack on 17 March 2020. WAFIC receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future. *WAFIC Consultation Services* Santos emailed WAFIC on 5 February 2020 requesting to utilise their consultation service to assist in the identification of commercial fishers who should be consulted for this EP. WAFIC responded on 11 February 2020 providing advice on which commercial fisheries overlap the Ningaloo Vision site and whether they are "relevant and potentially affected parties" to the Ningaloo Vision activities and therefore need to be consulted regarding the five-year review EP. In summary, this included: + North West Slope Trawl (noting the same licence holders in this fishery also hold the licences in the Western Deepwater Trawl). + Western Tuna and Billfish Fishery (one potentially active fisher)

- Southern Bluefin Tuna Fishery (consultation required with ASBTIA, not individual licence holders)
- Pilbara line fishery

WAFIC also provided advice on information to provide to commercial fishers.

Santos provided a draft consultation email to WAFIC for revision on 12 February 2020, and following further input from WAFIC, the final consultation email to commercial fishers was agreed on 13 February 2020.

WAFIC circulated Santos' revised *Ningaloo Vision* Operations Environment Plan Revision consultation package via email to the agreed commercial fishers on 13 February 2020. This included:

- Northwest Slope Trawl (three companies in the fishery)
- Western Tuna and Billfish fishery (one company actively operating in this fishery)

Pilbara Line – all licence holders in this fishery.

Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
[INFORMATION 001] Santos accepts WAFICs feedback and has since taken steps to actively work with WAFIC to improve the presentation and relevance of material in its consultation packs for commercial fishers.	Santos responded to WAFIC and accepted their feedback.
[REQUEST 001] In the revision of this EP, Santos has consulted with the relevant peak fishery bodies, including WAFIC, ASBTIA, CFA and Recfishwest (refer Table 4.1). In addition, Santos reviews and updates relevant data available from DPIRD to identify the fisheries and fishers who may be impacted by activities in the operational area. More recently, Santos has chosen to utilise the WAFIC Fee for Service to help identify the specific fishers who may be active in the operational area and to communicate more effectively with these operators. All listed fisheries are described in **Section 3.2.5**, and potential impact to fisheries, fish habitat and commercial fishers are discussed in **Section 6.5**.	Santos responded to WAFIC and addressed their request.
[REQUEST 002] A designated FPSO Person in Charge (PIC) is present on the FPSO at all times and is responsible for the activity. This dedicated role is staffed by personnel who have a full understanding of rules and regulations regarding access and is clear on the difference between	Santos responded to WAFIC and addressed their request.

	cautionary zones and the 500m PSZ. A control is included in the EP in **Table 8-2**.	
	[REQUEST 003] Santos contracts reputable and experienced vessel contractors to undertake its offshore vessel-based activities. These operators meet all of the relevant maritime legislation requirements and responsibly manage their interactions with other marine users, including commercial fishers, when undertaking activities. Applicable maritime controls are included in **Table 8-2**.	Santos responded to WAFIC and addressed their request.
	[REQUEST 004] Santos notes WAFIC's suggestion. Decommissioning and well abandonment activities will be the subject to a separate EP at some time in the future and Santos commits to consulting with WAFIC and other stakeholders at this time.	Santos responded to WAFIC and noted their request.
	[REQUEST 005] The Table appearing on page three of the Consultation Pack does not appear in the final EP and is used for consultation purposes only. Santos has now revised this table to ensure it also includes reference to commercial fishing activities.	Santos responded to WAFIC and accepted their feedback.
	[REQUEST 006] There is no change to Santos's policy on fishing from support vessels. All vessel contractors are required to acknowledge and sign a statement of conformance which includes the requirement that fishing from vessels is prohibited. This is undertaken both pre-mobilisation and post-mobilisation to confirm adherence to Santos requirements.	Santos responded to WAFIC and addressed their request.
Commonwealth Fisheries Association (CFA)	CFA was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. CFA receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims,**

		information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	ASBTIA was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. ASBTIA receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Recfishwest	Recfishwest was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019. Recfishwest responded to the consultation pack via email on 28 May 2019 advising that given the distance from shore, these activities are unlikely to impact their constituents, and recommend Santos contact the Exmouth Game Fishing Club (EGFC) for feedback. **[INFORMATION 001]** Santos responded to Recfishwest on 28 May 2019 confirming the EGFC had been included in the consultation. Recfishwest was provided a revised *Ningaloo Vision* Operations Environment Plan Revision consultation package via email on 13 February 2020. No additional comments were received from Recfishwest. Recfishwest receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	

	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	[INFORMATION 001] Santos included the Exmouth Game Fishing Club (EGFC) in consultation for this EP (see Table 4-2).	Santos responded to Recfishwest and confirmed EGFC had been included in the consultation process.
Marine Tourism WA (MTWA)	MTWA was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. MTWA receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Exmouth Community		
Cape Conservation Group (CCG)	CCG was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 25 February 2019, including an invitation to meet to discuss the EP revision in more detail. CCG responded on 3 March 2019 advising that to be able to participate in consultation and provide feedback, CCG would need a much greater level of detail on every environmental risk mitigation measure raised in the EP. CCG suggested the easiest way to enable this would be to provide a copy of the proposed draft EP (or draft EP summary) and a table showing the changes that have been made from the previously accepted version. **[REQUEST 001]** Santos responded to CCG on 6 March 2019 and accepted CCG request to review sections of the EP when available (refer assessment of stakeholder objections and claims).	

	CCG responded on 8 March 2019 advising they would appreciate access to revise the plan in greater detail – especially the environmental risk assessment and mitigation measures as mentioned when available and prior to submission to the regulator. **[REQUEST 002]** Through participation on the Exmouth Community Reference Group (refer Table 4-1), the CCG emailed Santos on 4 March 2019 requesting: + In relation to the World Bank's Zero Routine Flaring by 2030 initiative, the CCG asked Santos to provide a brief outline of how this will change operations for its local facility, including expected time frames and voluntary changes for those facilities which are greater than 22km from the coast. **[REQUEST 003]** + The CCG also asked a question regarding the decision-making process for use of dispersants **[REQUEST 004].** CCG emailed Santos on 8 March 2019 requesting Santos provide responses to questions asked in writing**. [REQUEST 005]**. Santos responded to CCG on 2 May 2019 and addressed each of the matters raised in their correspondence of 4 March 2019 and 8 March 2019 (refer assessment of stakeholder objections and claims). Following the 8 August 2019 Exmouth Community Reference Group meeting, CCG emailed Santos on 8 August 2019 confirming their interest in reviewing the Ningaloo Vision Operational EP when available. **[REQUEST 006]** Santos responded on 16 August 2019 advising Santos is more than happy for the CCG to review the Ningaloo Vision Operation EP and will liaise with the CCG when it is ready for review (refer assessment of stakeholder objections and claims). Santos emailed the revised *Ningaloo Vision Operations Environment Plan Revision Consultation Package* to the CCG on 3 March 2020. Santos advised it would provide a brief on the EP at the next meeting of the Exmouth Community Reference Group scheduled for Thursday 12 March 2020 and offered the CCG a separate briefing. Santos acknowledged that the CCG has requested to review sections of the EP, specifically the sections relating to environmental risk mitigation measures. Santos committed to provide a copy of those sections to the CCG as soon as possible. Further, Santos committed to address and include any comments from the CCG in the subsequent revisions of the EP during its assessment period with NOPSEMA. Santos confirmed that while there is no public comment period on the EP, the EP will be made available on the NOPSEMA website. Santos emailed CCG on 14 April 2020 advising the Ningaloo Vision Operations Environment Plan Revision was submitted to NOPSEMA on 31 March 2020 and is now being assessed in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Santos provided a link to the EP available on the NOPSEMA website. CCG responded on 20 May 2020 and 22 May 2020 and provided the following comments: + FPSO acts as a Fish Attracting Device (FAD) when in-situ and has not been adequately considered in the impact risk assessment. *CCG email of 22 May 2020.* **[CLAIM 001]**

Santos

	+ How can such a precedential change in industry practice occur within this EP without vigorous investigation of the impacts of permanent overboard discharge of produced water? For a change in industry standards CCG would recommend a comprehensive, independent investigation into the impacts and implications. *CCG email of 22 May 2020.* **[REQUEST 007]** + CCG strongly opposes the inclusion of "permanent overboard discharge of produced water" and requests this is removed from the approved EP. *CCG email of 22 May 2020*. **[OBJECTION 001]** + CCG submit that short-term discharges of produced water are given clear time-limits. CCG email of 22 May 2020 **[REQUEST 008]** + Water quality monitoring should be at closer intervals. *CCG email of 22 May 2020.* **[REQUEST 009]** + CCG advocate the inclusion of a requirement for referral under the EPBC Act to meet the approval condition (EPBC 2011/5995). *CCG email of 22 May 2020.* **[REQUEST 010]** + Has there been a proposed change to the allowable conditions for discharge of produced water and if so could you please provide an overview? *CCG email of 20 May 2020.* **[REQUEST 011]** + On page 238 of the EP, it states that "No stakeholder concerns directly specific to the revised 5-year EP have been raised regarding atmospheric emissions for the Ningaloo Vision Operations." However, no reference was made to CCGs recent requests for information about atmospheric emissions by the Ningaloo Vision (pg.238). *CCG email of 22 May 2020.* **[INFORMATION 001]** + CCG recommend that the atmospheric emissions are scrutinised for reductions using the ALARP Principle. *CCG email of 22 May 2020.* **[REQUEST 012]** + Flaring on the Van Gogh to date and anticipated future level of flaring. *CCG email of 20 May 2020* **[REQUEST 013]** + CCG would appreciate receiving further detailed information about the use of heat treatment to rid ballast water of invasive marine species (pg. 308). We note the cooling water discharges reach 100 degrees (pg. 251). Given the single hull on the underside of the FPSO, we would like to know if the two could be combined to reduce hot water discharges and decrease ballast IMS? *CCG email of 22 May 2020.* **[REQUEST 014].** + Is there a commitment on every dry dock to conduct treatment for hull biofouling (pg. 309)? If not, CCG recommend a commitment at every dry dock for IMS antifouling to take place. *CCG email of 22 May 2020* **[REQUEST 015]** + CCG recommend that equipment/infrastructure inspections are done post natural seismic and tsunami events over a predetermined strength. *CCG email of 22 May 2020*. **[REQUEST 016]** + CCG note that on page 70 the distance to the NCWHA is listed as 3kms further away than the Commonwealth Waters of the Ningaloo Marine Park. Please note the Commonwealth waters of the Ningaloo Marine Park is included in the NCWHA. *CCG email of 22 May 2020*. **[INFORMATION 002]**

	Santos responded to CCG on 10 July 2020 and addressed each of the matters raised in their correspondence of 20 and 22 May 2020 (refer assessment of stakeholder objections and claims). Santos is more than happy to arrange a meeting with the CCG to discuss these issues in greater detail if required. CCG receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No additional feedback received from the CCG to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	[REQUEST 001] Santos advised it would be able to provide detail of the Ningaloo Vision Operations EP to the CCG, specifically the sections relating to environmental risk mitigation measures, as requested. Santos confirmed the new transparency reforms would require Operations EPs to be published upon first submission to NOPSEMA, and again following acceptance. Santos advised the EP development had not yet commenced and it would keep the CCG informed of its progress, and when relevant information will be available. Santos offered to meet.	Santos responded to CCG and accepted their request to review section of the EP when available.
	[REQUEST 002] As above, Santos has advised the CCG a copy of the Ningaloo Vision Operations EP will be made available. Santos advised the EP development had not yet commenced and it would keep the CCG informed of its progress, and when relevant information will be available.	No response required.
	[REQUEST 003] Santos responded to CCG on 2 May 2019 advising Santos supports sensible initiatives to reduce emissions from oil and gas activities. Consistent with this, it is our long-term aspiration to achieve net-zero emissions for our operations by 2050, in line with global ambitions to limit temperature rise to well below 2 degrees Celsius. In the short-term, Santos is achieving its emissions intensity targets and undertaking many initiatives in pursuit of emissions reductions, including daily processes to optimise fuel use,	Santos responded to the CCG and provided the information requested.

	flaring and venting at all operated facilities. Santos advised companies are required to provide emissions data through the Clean Energy Regulator which is publicly available. Santos also provided a copy of its Climate Change Report. The requirement for emissions reporting is within **Table** 8-4	
	[REQUEST 004] Santos provided the CCG information regarding the decision-making process for use of dispersants. Discussion on the potential use of dispersants is included in **Section 6.8**.	Santos responded to the CCG and provided the information requested.
	[REQUEST 005] Santos understands that open and transparent communications are critical to being a responsible and trusted community member. Santos commits to actively listening to community concerns and expectations. Santos commits to responding to all stakeholder queries. Where requested, Santos will provide appropriate responses in writing.	Santos responded to the CCG and agreed with their request.
	[REQUEST 006] Santos supports the CCG request to review the Ningaloo Vision Operation EP and will liaise with the CCG when it is ready for review. Santos advised completion was still some months away, however committed to keep the CCG informed. As part of this review, Santos offered a more detailed briefing on the EP for the CCG.	Santos responded to the CCG and agreed with their request.
	[CLAIM 001] FPSO acts as a Fish Attracting Device (FAD) when in-situ and has not been adequately considered in the impact risk assessment. *CCG email of 22 May 2020.*	Santos responded to the CCG and advised Santos has no scientific or anecdotal evidence that the FPSO acts as a fish attracting device when in-situ. As such, this has not been included within the EP and Santos do not propose a need to include reference to the FPSO being a FAD.
	[REQUEST 007] How can such a precedential change in industry practice occur within this EP without vigorous investigation of the impacts of permanent overboard discharge of produced water? For a change in industry standards CCG would recommend a comprehensive, independent investigation into the impacts and implications. *CCG email of 22 May 2020.*	Santos responded to the CCG and advised the overboard discharge of produced water in the NV EP is not a precedential change. The in-force EP currently allows for contingent overboard discharges. Santos has undertaken a comprehensive assessment of produced water, including chemical characterisation and ecotoxicology testing, and produced water dispersion

		modelling, to inform the risk and impact assessment (Section 6.7). These studies have been undertaken by subject matter experts, independent of Santos, and were used to inform the risk and impact assessment within the EP.
	[OBJECTION 001] CCG strongly opposes the inclusion of "permanent overboard discharge of produced water" and requests this is removed from the approved EP. *CCG email of 22 May 2020.*	Santos responded to the CCG and acknowledged that CCG is opposed to a permanent overboard discharge of produced water. Santos does not propose to remove the permanent produced water discharge activity from the NV EP. The permanent discharge of produced water is required only under a specific set of operating conditions and controls where the environmental risks and impacts are effective in managing the discharge of produced water.
	[REQUEST 008] CCG submit that short-term discharges of produced water are given clear time-limits. *CCG email of 22 May 2020.*	Santos responded to the CCG and noted the CCG's request that short term discharges should be given clear time limits. Santos has developed the produced water discharge proposal based on asset production need as well as environmental risk and impact consideration. Section 6.7 of the EP outlines that discharge scenario durations are risk based and not able to be clearly temporally bound. Santos is currently assessing the produced water scenarios to provide further detail on estimated time limits associated with produced water discharges within the next

		revision of the NV EP to be submitted to NOPSEMA.
	[REQUEST 009] Water quality monitoring should be at closer intervals. *CCG email of 22 May 2020.*	Santos responded to the CCG and advised Santos has included a requirement for water quality monitoring as part of a risk-based approach to managing potential impacts from produced water discharges within an Adaptive Management Plan (Appendix H of the NV EP). Water quality monitoring frequencies are considered commensurate to the potential risk and impacts, informed by the specialist studies undertaken (chemical characterisation, ecotoxicology and produced water dispersion modelling).
	[REQUEST 010] CCG advocate the inclusion of a requirement for referral under the EPBC Act to meet the approval condition (EPBC 2011/5995). *CCG email of 22 May 2020.*	Santos responded to the CCG and noted the CCG comment. Santos advised that it is liaising with the Department of Agriculture, Water and the Environment (DAWE) on the associated approvals under the *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act).
	[REQUEST 011] Has there been a proposed change to the allowable conditions for discharge of produced water and if so could you please provide an overview? *CCG email of 20 May 2020.*	Santos responded to the CCG and advised Santos has developed the produced water discharge proposal based on asset production need and the potential for non-routine operations to occur. In summary, Santos proposes three Produced Water Discharge scenarios. + Reinjection into the reservoir; + Temporary discharge to marine environment (with the intention to return to reinjection when upset condition resolved); and

		+ Permanent discharge to marine environment. Santos has had specialist studies undertaken and has applied controls to manage the risks and impacts such that they are ALARP and acceptable. Further detail on the scenarios can be found in Section 6.7 and Appendix H of the NV EP on the NOPSEMA website https://info.nopsema.gov.au/environment_plans/500/show_public
	[INFORMATION 001] On page 238 of the EP, it states that "No stakeholder concerns directly specific to the revised 5-year EP have been raised regarding atmospheric emissions for the Ningaloo Vision Operations." However, no reference was made to CCGs recent requests for information about atmospheric emissions by the Ningaloo Vision (pg.238). *CCG email of 22 May 2020.*	Santos responded to the CCG and acknowledged the CCG ongoing interest in flaring and has amended this section of the NV EP to reflect this.
	[REQUEST 012] CCG recommend that the atmospheric emissions are scrutinised for reductions using the ALARP Principle. *CCG email of 22 May 2020.*	Santos responded to the CCG and acknowledged the CCG recommendation. Santos referred CCG to Section 6.3.3 of the NV EP which outlines a number of controls considered in relation to reducing atmospheric emissions, as well as Section 6.3.5 which outlines the Santos ALARP position.
	[REQUEST 013] Flaring on the Van Gogh to date and anticipated future level of flaring. *CCG email of 20 May 2020.*	Santos responded to the CCG and advised Table 6-8 of the NV EP includes historical flaring volumes and emissions from the NV FPSO. Future flaring volumes /profile may change in the future, but regardless, emissions volumes will comply with the requirements of the National Greenhouse and Energy Reporting

		(Safeguard Mechanism) Rule 2015 (Safeguard Mechanism Rule).
	[REQUEST 014] CCG would appreciate receiving further detailed information about the use of heat treatment to rid ballast water of invasive marine species (pg. 308). We note the cooling water discharges reach 100 degrees (pg. 251). Given the single hull on the underside of the FPSO, we would like to know if the two could be combined to reduce hot water discharges and decrease ballast IMS? C*CG email of 22 May 2020.*	Santos responded to the CCG and advised Santos manages Ballast Water pursuant to the Biosecurity Act 2015 and Australian Ballast Water Management Requirements 2017 as reflected in Control Measure 41 in Table 8-2 of the NV EP. Heat treatment of ballast is not a mandatory requirement of the Australian Ballast Water Management Requirements 2017. Santos has considered and rejected it as an option within Section 7.1.3 of the EP because it has a high cost compared to the existing Invasive Marine Species (IMS) risk and effective controls already in place. Furthermore, pipe work modifications on the FPSO are not feasible (to combine ballast discharge with cooling water streams) due to the segregated ballast design of the vessel being in compliance with MARPOL requirements.
	[REQUEST 015] Is there a commitment on every dry dock to conduct treatment for hull biofouling (pg. 309)? If not, CCG recommend a commitment at every dry dock for IMS antifouling to take place. *CCG email of 22 May 2020.*	Santos responded to the CCG and advised there is no legal requirement, nor commitment within the NV EP to conduct treatment for hull biofouling at every dry dock. Antifouling treatments remain effective longer than the 5 yearly dry dock cycle. Nonetheless, it is important to note that Santos manages the risk of IMS with its IMS Management Plan (IMSMP). The IMSMP has been developed using a risk-based approach for the

		management of IMS risk and compliance with regulatory requirements. Through the application of the IMSMP, Santos' approach towards the management of IMS is consistent with, and compliant with current International, Commonwealth, State and Territory IMS management practices.
	[REQUEST 016] CCG recommend that equipment/infrastructure inspections are done post natural seismic and tsunami events over a predetermined strength. *CCG email of 22 May 2020.*	Santos responded to the CCG, acknowledged the CCG's recommendation and advised that seismic activity is an engineering consideration during the basis of design phase of infrastructure development. As such, infrastructure is designed to withstand seismic related activity applicable to the location of the development.
	[INFORMATION 002] CCG note that on page 70 the distance to the NCWHA is listed as 3kms further away than the Commonwealth Waters of the Ningaloo Marine Park. Please note the Commonwealth waters of the Ningaloo Marine Park is included in the NCWHA. *CCG email of 22 May 2020.*	Santos responded to the CCG and advised Santos has reassessed the distance and made an amendment to Page 70.
Ningaloo Coast World Heritage Advisory Committee (NCWHAC)	NCWHAC was provided the *Ningaloo Vision* Operations Environment Plan Revision consultation package via email on 6 March 2019. NCWHAC responded on 12 June 2019 with the following comments: + Note that the NCWHAC has not been able to address the current EP and that proposed revisions to the EP were not available at the time of submission. We ask that these comments be addressed in the revised EP. **[REQUEST 001]** + The consultation package provided very little detail about the revisions proposed, or about specific activities which occur inside and adjacent to the World Heritage area. [**CLAIM 001**] + Anchoring or dynamic positioning by tankers and supply/ support vessels. The Committee is aware that the area surrounding the Muiron Islands is commonly used as a shelter for vessels including large tankers. In order to make an assessment of the any potential impact to the OUV of the NCWHA, could you please provide information on sites used within and adjacent to	

	the World Heritage area, vessel frequency, type and positioning (anchored or dynamic). It would be very useful to have a map showing this detail overlaid with the World Heritage boundary. **[REQUEST 002]**
	+ We understand that vessels traverse through the NCWHA (between the tip of the North West Cape and the Muiron Islands) using the designated shipping lane. This is also the preferred southern migration route for humpback whales (females and calves) exiting from Exmouth Gulf before migrating to Antarctica. The northern end of Exmouth Gulf is also a known area for aggregations of dugongs and dolphins. The revised EP should state how Santos vessels will avoid collisions with migrating whales and with local populations of dolphins and dugongs. **[REQUEST 003]**
	+ Oil spills in waters adjacent to the NCWHA is a key concern for the Committee. Oil spills have been identified by the IUCN, "risk of oil spills remains the greatest threat, as well as associated shipping" to the NCWHA. The risk is exacerbated by limited access to the remote coastline in the event of an oil spill. The revised EP should provide for on-going review of oil spill prevention, management and response measures; and publication of these reviews. As noted above the IUCN rated "associated shipping" with oil spills as the greatest threat to NCHWA. The Committee is aware the area near the NCWHA is being used by oil tankers from the following Santos descriptions of activities
	  + "Activities at this location include… local vessels transfer Santos marine pilots to the 'Boarding Ground', to board offtake tankers". Offtake tankers do not anchor here, as it is within the defined 'offtake tanker anchorage exclusion area'.
	  + Vessels do not anchor at the Pilot Boarding Ground (3.55 km from World Heritage Area), this is a designated safe location for transfer of Marine Pilots (personnel) onto Tankers before they proceed to berth at any of the FPSO Terminals. No other activities take place there.
	  + The 'North Anchorage 1' anchoring location within the Gulf, which is 2.91 km from the World Heritage Area, is a location for safe anchoring. It would be unusual for any other activity to occur in this location, as vessel transfers of equipment are more likely to occur closer to the Marine."
	+ We understand that the above usage of areas adjacent to the NCWHA is within specified anchorage and boarding grounds. Nevertheless, there are risks associated with having fully loaded tankers using these sites, including the risk of ship - ship collisions. There is also the risk of collisions by ships with marine mammals during travel to and from the sites (for example humpback whales travel from Exmouth Gulf through the passage between Muiron Islands and the North West Cape before heading south to Antarctica – the preferred route for ships). **[REQUEST 004]**
	+ We continue to urge Santos to describe and quantify the risks of their proposed activities to the OUV of the World Heritage area and we therefore recommend that the revised EP include provision for the following: **[REQUEST 005]**
	  + Is use of these sites covered by the Operational EP and OSCP (Oil Spill Contingency Plan) – including spill modelling?
	  + What mitigation measures are in place to reduce the risk of oil spill at these locations?
	  + Has there been any reportable oil spills at these locations to date?

<table>
<tr><td rowspan="5"></td><td colspan="2">+ What shipping routes (official/unofficial) are used accessing these sites (a map and information about frequency of use and vessel type would be useful).
+ What measures are in place to reduce the risk of marine mammal collisions by ships traversing the passage between Muiron Islands and the Northwest Cape?
+ Has there been any reports of marine mammal collision to date?
Santos met with the World Heritage Program Manager in Exmouth on 2 August 2019 to discuss the NCWHAC comments.
Santos responded to NCWHAC on 4 March 2020 and addressed each of the matters raised in their correspondence of 12 June 2020 (refer assessment of stakeholder objections and claims).
NCWHAC was emailed a copy of the revised Ningaloo Vision Operations Environment Plan Revision consultation package on 4 March 2020.
Santos emailed NCWHAC on 4 March 2020 and offered to discuss EP revision in more detail.
No further comments received from the NCWHAC.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>[REQUEST 001] Santos acknowledges that the Ningaloo Coast World Heritage Advisory Council has requested to review sections of the EP, specifically the sections relating to environmental risk mitigation measures. Santos commits to provide a copy of those sections to the council as soon as possible. Further, Santos commits to address and include any additional comments the council may have in the subsequent revisions of the EP during its assessment period with NOPSEMA. While there is no public comment period on the EP, the EP will be made available on the NOPSEMA website.</td><td>Santos responded to NCWHAC and advised how their request would be addressed.</td></tr>
<tr><td>[CLAIM 001] Santos has offered to meet with the council to provide a more detailed briefing on the EP before it is submitted to NOPSEMA.</td><td>Santos responded to NCWHAC and advised how their claim would be addressed.</td></tr>
<tr><td>[REQUEST 002] In the EP, vessel activity is covered for the operational area only, (which was shown in an attached map (Map 1)). For vessel activities associated with Ningaloo Vision operations outside of this area, management measures are implemented under Santos Protected Marine Fauna Interaction and Sighting Procedure, which requires vessels to abide by Part 8</td><td>Santos responded to NCWHAC and provided the information requested.</td></tr>
</table>

	of the EPBC Regulations. Additional measures are required for vessels within Exmouth Gulf during whale resting season (1 August – 31 October) whereby vessels are restricted to speeds of under 8 knots and vessel crew are required to act as fauna observers. Santos notes recent EPA advice stating that activities requiring heavy lift operations in Exmouth Gulf will need to be referred to the WA EPA for assessment under Section 38 of the EP Act. A map (Map 2) was provided which helps to illustrate Exmouth Gulf Anchorage Locations. Currently, the offshore support vessel (OSV) for the *Ningaloo Vision* is the Mermaid Cove (specifications attached). Additional support is provided on an as needs basis by smaller jet-propelled utility vessels. OSVs contracted by Santos do not generally use Exmouth Gulf, except for crew changes from time to time. The smaller vessels hired by Santos generally operate out of Exmouth Marina and are used for sending urgent deliveries to *Ningaloo Vision*, boarding marine pilots to offtake tankers or assisting with Ningaloo Vision's reconnection activities after a cyclone when the vessel returns. Generally, vessels do not anchor in Exmouth Gulf. However, on occasion there may be a need to anchor in the gulf, such as when waiting for a berth at the marina. There are dedicated anchoring areas provided to Santos chartered vessels. The Mermaid Cove will anchor between Muiron Island and Sunday Island when on standby. Offtake tankers do not enter or anchor in the Exmouth Gulf at any time. Additionally, Offtake tankers are instructed not to anchor in the anchorage exclusion area.	
	[REQUEST 003] Santos advised NCWHAC the activities identified in this request are addressed in separate and supporting management plans. All vessels contracted to Santos are required to implement the Protected Marine Fauna Interaction and Sighting Procedure which requires vessels at all times to abide by Part 8 of the Environmental Protection and Biodiversity Conservation Regulations for the protection of marine fauna. Additional measures for vessels in Exmouth Gulf are detailed above.	Santos responded to NCWHAC and provided the information requested.

	[REQUEST 004] Oil spill prevention and response measures are included in the Environment Plan and the Oil Pollution Emergency Plan (OPEP), respectively, for those activities within the operational area. For oil spill response arrangements this includes regular testing of arrangements, equipment and key response personnel through exercises, and internal auditing programs. Santos is able to provide the Committee further information on recently conducted oil spill response assurance activities and those planned. Findings of assurance activities may result in the update of response arrangements included in the OPEP. The OPEP is published on the Santos website as per Ministerial Condition requirements associated with the EPBC Act referral for the Van Gogh development. Santos is also actively involved in oil spill response industry and regulator led working groups and forums and has contracts with the major Australian and global spill response organisations. Through these networks, Santos keeps abreast of any improvements or changes in spill response arrangements.	Santos responded to NCWHAC and provided the information requested.
	[REQUEST 005] Santos provided the following information to NCWHAC: + Risks from oil tanker activities are only included in the EP when they are within the operational area defined in the EP. The OPEP includes responses to minimise impacts to the OUV of the World Heritage Area if a spill related to those tanker activities were to occur. Outside of the operational area, the activities of offtake tankers are under international and national maritime law. + All oil tankers servicing *Ningaloo Vision* are operated by reputable international shipping companies. They follow stringent HSE requirements under IMO governed by AMSA in Australian waters. In addition, these tankers must meet stringent Santos preselection criteria prior to being approved for loading at Ningaloo Vision Terminal. + There has been no reported oil spill from an offtake tanker since the commencement of production activities at Ningaloo Vision. + Please refer to shipping fairways map of the North west shelf produced by AMSA (Map 3). Shipping lanes are located to the north and west of Exmouth gulf.	Santos responded to NCWHAC and provided the information requested.

	+ Vessels are required to abide by Part 8 of the EPBC Regulations as described previously. + No reports of marine mammal collision to date related to Santos activities. Procedure requires reporting of all sightings and interactions with marine fauna.	
Exmouth Shire	Exmouth Shire was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 6 March 2019 and a revised consultation package via email on 3 March 2020. The Shire receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. Santos met with the Exmouth Shire on 7 March 2019 to discuss the EP revision. The Shire had no comments on the revision. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
North West Cape Aboriginal Corporation	The Corporation was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via email on 13 February 2020. The Corporation receive all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.

<table>
<tr><td rowspan="3">Exmouth Volunteer Marine Rescue Group</td><td colspan="2">EVMRG was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
EVMRG receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
No comments received to date.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
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<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Exmouth Game Fishing Club</td><td colspan="2">EGFC was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
EGFC receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
No comments received to date.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
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<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>DBCA (Exmouth Regional Branch)</td><td colspan="2">DBCA was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
DBCA receive all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.</td></tr>
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<tr><td rowspan="3"></td><td colspan="2">See DBCA comments above.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">DOT (Exmouth Regional Branch)</td><td colspan="2">DOT was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
DOT receive all Santos’ WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
See DOT comments above.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
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<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="2">Exmouth Chamber of Commerce and Industry (CCI)</td><td colspan="2">The CCI was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
The Exmouth CCI receive all Santos’ WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
No comments received to date.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims,</td></tr>
</table>

		information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Gunn Marine Services	This stakeholder was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 6 March 2019 and a revised consultation package via email on 3 March 2020. This stakeholder receives all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Exmouth Freight and Logistics	This stakeholder was provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 6 March 2019 and a revised consultation package via email on 3 March 2020. This stakeholder receives all Santos' WA Quarterly Consultation Update documents. These updates list the *Ningaloo Vision* Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the *Ningaloo Vision* Operations EP is currently underway and due for submission Q2 2020. No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.

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<tr><td rowspan="3">Base Marine</td><td colspan="2">This stakeholder was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
This stakeholder receives all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
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<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Exmouth Tackle and Camping</td><td colspan="2">This stakeholder was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
This stakeholder receives all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.
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<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Exmouth Bus Charter</td><td colspan="2">This stakeholder was provided the Ningaloo Vision Operations Environment Plan Revision Consultation Package via email on 6 March 2019 and a revised consultation package via email on 3 March 2020.
This stakeholder receives all Santos' WA Quarterly Consultation Update documents. These updates list the Ningaloo Vision Operations as an ongoing activity, and since June 2019 has contained advice that the five yearly regulatory revision of the Ningaloo Vision Operations EP is currently underway and due for submission Q2 2020.</td></tr>
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	No comments received to date. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Exmouth Community Reference Group (CRG)	Members of the Exmouth CRG were provided a detailed briefing on the *Ningaloo Vision* Operations Environment Plan Revision at a meeting on 6 March 2019. Updates were provided at the meetings on 8 August 2019 and 7 November 2019 and a further detailed briefing provided at the meeting held on 12 March 2020. The Cape Conservation Group provided comment on the EP through this process, and their comments are addressed separately in Table 4.2. No other formal comments on the EP were received through this process. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder group should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Commercial fisheries - state managed		
Pilbara Line Fishery	Relevant stakeholders in this fishery were provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via WAFIC on behalf of Santos 13 February 2020. All licence holders in this fishery were consulted. No comments received to date. Refer WAFIC comments in Table 4.2. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims,**

		information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Commercial fisheries - commonwealth managed		
North West Slope Trawl	Relevant stakeholders in this fishery were provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via WAFIC on behalf of Santos on 13 February 2020. On advice from WAFIC, the same licence holders in this fishery also hold the licences in the Western Deepwater Trawl (boundary very close by). Three fishers in this fishery have been consulted. No comments received to date. Refer WAFIC comments in Table 4.2. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Southern Bluefin Tuna Fishery	On advice from WAFIC, Santos has consulted with the Australian Southern Bluefin Industry Association (ASBTIA) on this EP revision, not individual licence holders. Refer ASBTIA and WAFIC comments in Table 4.2. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required.	No response required.
Western Tuna and Billfish Fishery	Relevant stakeholders in this fishery were provided the *Ningaloo Vision Operations Environment Plan Revision Consultation Package* via email on 27 May 2019 and a revised consultation package via WAFIC on behalf of Santos on 13 February 2020.	

	On advice from WAFIC, one fisher is potentially active near the operational area and should be consulted. No comments received to date. Refer WAFIC comments in Table 4.2. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	**Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))**
	No assessment required	No response required.

4.5 Ongoing Consultation

Santos provides relevant stakeholders with ongoing consultation for regulatory purposes and to ensure community stakeholders are engaged and informed of Santos's activities in the region. Santos will work with stakeholders to address any future concerns if they arise throughout the duration of this EP. Should new stakeholders be identified (**Section 4.1**), they will be added to the stakeholder database and included in all future correspondence as required, including activity-specific notifications and updates.

Santos, as a marine user, understands there will be the need to interact and communicate with other marine users to ensure mutual and individual stakeholder goals are met. Santos has identified the need for ongoing engagement with the local community and the fishing industry.

Stakeholders will be notified of any activities relating to the NV Operations which may impact upon their interests. These activities could be maintenance or ongoing monitoring activities and may include temporary increased vessel activity. Notifications will be provided to relevant stakeholders when required only, and while Santos does not expect concerns to be raised regarding activities at the Ningaloo Vision, if additional comments do arise Santos will allow an appropriate amount of time to respond and address these comments.

4.6 Exmouth Community Reference Group

The Exmouth Community Reference Group is convened three times a year in Exmouth, in collaboration with neighbouring oil and gas operators. Meetings cover operational updates, as well as outlining any upcoming activities which may have impact on the region. Members are provided with project-specific briefings at these meetings to facilitate the raising of comments or concerns directly with Santos via email, telephone conversation or at the meetings.

The membership of this group is diverse and currently includes about 50 community representatives.

4.7 Quarterly Consultation Update

Activities covered under this EP will be included in Santos' Quarterly Consultation Update until they can be listed as a 'completed activity', with updates scheduled for approximately March, June, September and December annually.

The NV Operations EP revision has been included in Santos' Quarterly Consultation Updates distributed in June 2019, October 2019 and January 2020. No comments regarding the operation were received in response to this consultation. This document is provided in **Appendix E**.

The Quarterly Consultation Update is circulated to a broad group of Santos stakeholders, including many of the stakeholders identified in **Table 4-2.**

If stakeholders request additional information or raise concerns on any activity listed in a Quarterly Consultation Update, a dialogue with these stakeholders can continue during or post the preparation of an EP and will be recorded for future reference. Santos commits to respond and address any comments to the satisfaction of both parties and keep any consultation on file during and post acceptance of an EP.

4.8 Addressing Consultation Feedback

Santos' Consultation Coordinator is available before, during and after the activity to ensure opportunities for stakeholders to provide feedback are available.

Santos will maintain records of all stakeholder consultation related this this EP and activity.

4.9 Stakeholder-related Control Measures, Performance Outcomes and Standards

Control measures and performance outcomes and standards for stakeholder consultation are included in **Table 8-2.**

If, in stakeholder consultation, a change to any control measure or activity outlined in this EP is required, Santos will undertake an internal assessment using the management of change process **Section 8.12.2.**

5 Environmental Impact and Risk Assessment Methodology

OPGGS(E)R 2009 Requirements
Regulation 13. Environmental assessment
Evaluation of environmental impacts and risks 13(5) The environment plan must include: (a) details of the environmental impacts and risks for the activity; and (b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and (c) details of the control measures that will be used to reduce the impacts and risks of the activity to as low as reasonably practicable and an acceptable level. 13(6) To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.

Environmental impact and risk assessment refers to a process whereby planned and unplanned events that will or may occur during an activity are quantitatively and/or qualitatively assessed for their impacts on the environment (physical, biological, and socio-economic) at a defined location and specified period of time. In addition, unplanned events are assessed on the basis of their likelihood of occurrence which contributes to their level of risk.

Santos WA has undertaken environmental impact and risk assessments for the planned events (including any routine, non-routine and contingency activities) and unplanned events in accordance with the OPGGS(E)R.

Provided in this section of the EP is the following information relating to the environmental impact and risk assessment approach:

+ Terminology used; and
+ Summary of the approach.

A full description of the process applied in identifying, analysing and evaluating the impacts and risks relating to the planned activity is documented in *Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline* (EA-91-IG-00004_5).

5.1 Impact and Risk Assessment Methodology

Common terms applied during the impact and risk assessment process, and used in this EP, are defined in **Table 5-1**. For a more comprehensive listing of the terms and definitions used in environmental impact and risk assessment, refer to *Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline* (EA-91-IG-00004_5).

Table 5-1: Impact and Risk Assessment Terms and Definitions

Name	Definition
Acceptability	Determined for both impacts and risks. Acceptability of events is in part determined by the consequence of the impact following management controls. Acceptability of unplanned events is in part determined from its risk ranking following management controls. For both impacts and risks, acceptability is also determined from a demonstration of the ALARP principle, consistency with Santos Policies, consistency with all applicable legislation and consideration of relevant stakeholder consultation when determining management controls.

Name	Definition
Activity	Specific tasks and actions undertaken throughout the life cycle of oil and gas exploration, production and decommissioning.
ALARP	As Low As Reasonably Practicable The term refers to reducing risk to a level that is As Low As Reasonably Practicable. In practice, this means showing through reasoned and supported arguments, that there are no other practicable options that could reasonably be adopted to reduce risks further.
Authorised Person	Person with authority to make the decision or take the action. Examples are Vessel Master, Field Superintendent, Supervisor, Person-in-charge, Company Authorised Representative, and Project Manager.
Control Measure	Means a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks[1].
DMIRS	Department of Mines, Industry Regulation and Safety
Environment	Includes the natural and socio-economic values and sensitivities which will or may be affected by the activity. Is defined by NOPSEMA and DMIRS as: (a) ecosystems and their constituent parts, including people and communities; and (b) natural and physical resources; and (c) the qualities and characteristics of locations, places and areas; and (d) the heritage value of places. (e) the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).
Environmental consequence	A consequence is the outcome of an event affecting objectives. Note 1 An event can be one or more occurrences and can have several cases. Note 2 An event can consist of something not happening. (Reference ISO 73:2009 Risk Vocabulary)
Environmental impact	Defined by NOPSEMA[1] as any change to the environment, whether adverse or beneficial, wholly or partly resulting from a planned or unplanned event[1.] Defined by DMIRS[2] as any change to the environment, whether adverse or beneficial, that wholly or partly results from a petroleum activity of an operator.
ENVID	Environmental hazard identification workshop
Environmental risk	Applies to unplanned events. Risk is a function of the likelihood of the unplanned event occurring and the consequence of the environmental impact that arises from that event.
Hazard	A situation with the potential to cause harm
Grossly disproportionate	Where the sacrifice (cost and effort) of implementing a control measure to reduce impact or risk, grossly exceeds the environmental benefit to be gained.

[1] Defined by the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009

Name	Definition
Impact assessment	The process of determining the consequence of an impact (in terms of the consequence to the environment) arising from a planned or unplanned event over a specified period of time.
Likelihood	The chance of an unplanned event occurring.
Non-routine planned event	An attribute of the planned activity that may occur or will occur infrequently during the planned activity. A non-routine planned event is intended to occur at the time.
Planned activity	A description of the activity to be undertaken including the services, equipment, products, assets, personnel, timing, duration and location and aspect of the activity.
Planned event	An event arising from the activity which is done with intent (i.e. not an unplanned event) and has some level of environmental impact. A planned event could be routine (expected to occur consistently throughout the activity) or non-routine (may occur infrequently if at all). Air emissions, bilge water discharge and drill cuttings discharge would be examples of planned events.
Receptor	A feature of the environment that may have environmental, social and/ or economic values.
Risk	The effect of uncertainty on objectives.
Risk assessment	The process of determining the likelihood of an unplanned event and the consequence of the impact (in terms of economic, human safety and health, or ecological effects) arising from the event over a specified period of time.
Routine planned event	An attribute of the planned activity that results in some level of environmental impact and will occur continuously or frequently through the duration of the planned activity
SLT	Senior Leadership Team
Unplanned event	An event that results in some level of environmental impact and may occur despite preventative safeguards and control measures being in place. An unplanned event is not intended to occur during the activity.

5.2 Summary of the Environmental Impact and Risk Assessment Approach

5.2.1 Overview

Santos operates under an overarching Risk Management Policy (QE-91-IF-10050). The company Risk Procedure (SMS MS1 ST01) underpins the Risk Management Policy and is consistent with the requirements of AS/NZS ISO 31000:2018, Risk Management – Guidelines (ISO, 2018).

The key steps to risk management are illustrated in **Figure** 5-1. The forum used to undertake the assessment is the environmental hazard workshop, referred to as an ENVID, which is described in Section 4 of *Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline* (EA-91-IG-00004_5).

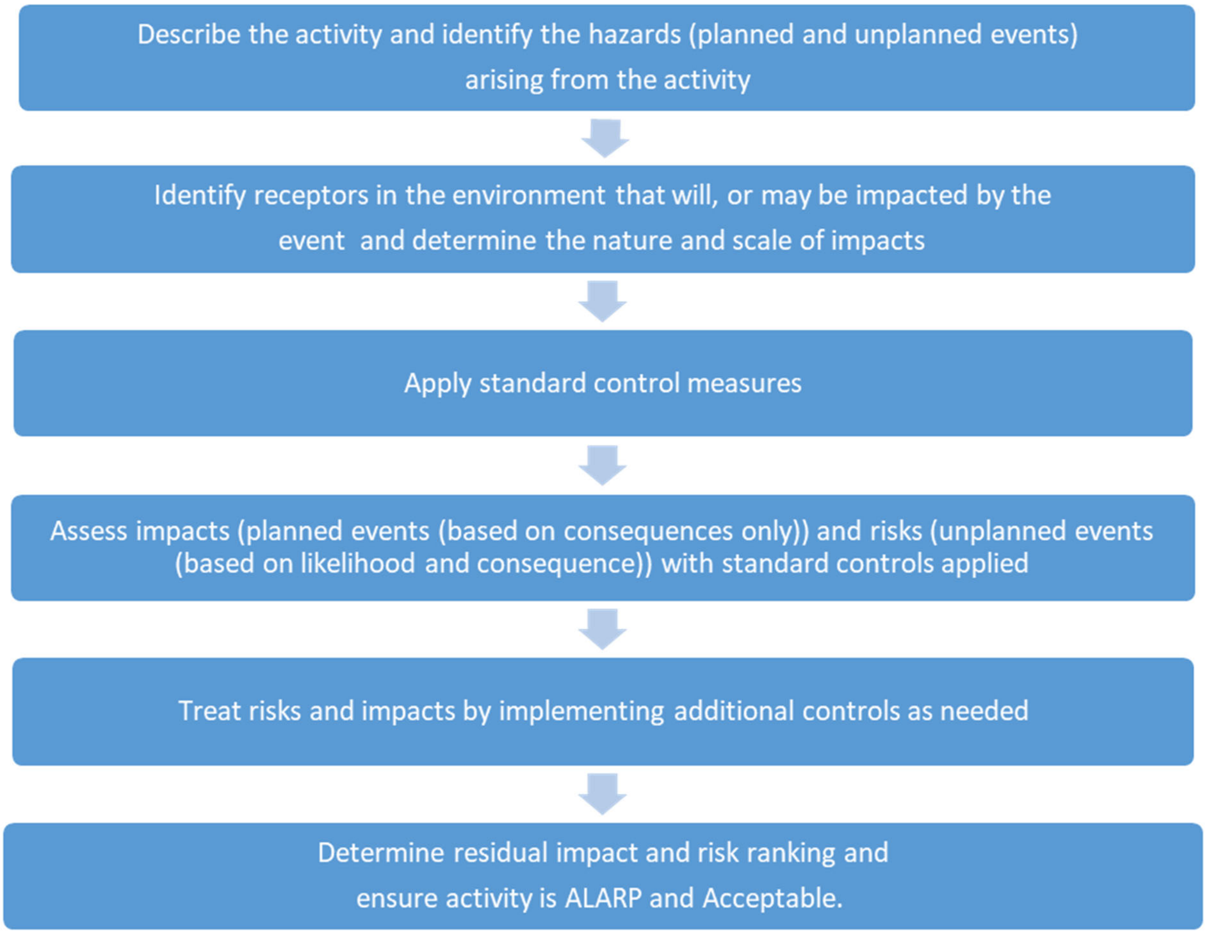

Figure 5-1: Environmental Impact and Risk Assessment Process

Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline (EA-91-IG-00004_5) includes consideration of the following key areas in an impact and risk assessment:

+ Description of the Activity (including location and timing);
+ Description of the environment (potentially affected by both planned and unplanned activities);
+ Identification of relevant persons;
+ Identification of legal requirements ('legislative controls') that apply to the Activity ;
+ Santos policy and SMS requirements;
+ Principles of Ecologically Sustainable Development (ESD); and

+ Santos acceptable levels of impact and risk .

These factors were considered in three environmental impact and risk assessment workshops held in April – June 2019 in which environmental impact identifications (ENVIDs) were made. The risk workshop involved participants from the Santos Health, Safety and Environment (HSE) and Operations departments and specialist environmental consultants.

5.2.2 Describe the Activity and Hazards (planned and unplanned events)

of this EP. A description of the activity (**Section 2**) is required in order to determine the planned events that will take place and the credible unplanned events that may occur. The location, timing and scope of the activity must be described in order to determine the impacts from planned events, and the impacts and risks from unplanned events since these have a bearing upon the environment that may be affected (EMBA) by the activity.

The outcome of this assessment is detailed in the relevant sub-sections of **Sections 6** and **7.**

5.2.3 Identify Receptors and Determine Nature and Scale of Impacts

A description of the environment (natural and socio-economic) within which hazards from the activity will, or may occur, is required. This constitutes a crucial stage of the risk assessment, as an understanding of the environment that will or may be affected is required to determine the type and consequence of impacts from the activity being assessed. The environment must be understood with respect to the spatial and temporal limits of the activity and key resources at risk that will or could be impacted by planned and unplanned events. Santos has developed a Values and Sensitivities of the Marine and Coastal Environment (EA-00-RI-10062) reference document which describes the existing environment that may be affected by Santos activities and is reviewed and updated on an annual basis.

Where the existing environment is being reviewed for regulatory approvals, a comparison shall be made against the Values and Sensitivities of the Marine and Coastal Environment (EA-00-RI-10062). A new protected matters search is required to ensure a thorough understanding of the existing environment to ensure all risks are assessed.

The extent of actual impacts from each planned activity or risks from each unplanned activity, are assessed using, where required, modelling (e.g. hydrocarbon spills) and scientific reports. The duration of the event is also described including the potential duration of any impacts should they occur

Receptors identified as potentially occurring within impacted area(s) are detailed in **Section 3** and **Appendix D1.**

5.3 Describe the Environmental Performance Outcomes and Control Measures

For each planned and unplanned event, a set of Environmental Performance Outcome(s), Control Measures, Environmental Performance Standards and Measurement Criteria are identified. The definitions of the performance outcomes, control measures, standards and measurement criteria must be consistent with the OPGGS(E)R 2009, and the NOPSEMA EP Content Requirements Guidance Note (NOPSEMA, 2019).

For any hazard, additional controls, must also be considered and either accepted for use or rejected based on whether the standard controls reduce impacts and risks to levels that are ALARP and acceptable.

Controls are allocated in order of preference according to **Figure 5-2**.

Control	Effectiveness	Example
Eliminate		*Removal of the risk.* Refueling of vessels at port eliminates the risks of an offshore refueling.
Substitute		*Change the risk for a lower one.* The use of low-toxicity chemicals that perform the same task as a more toxic additive.
Engineering		*Engineer out the risk.* The use of oil-in-water separator to minimise the volume of oil discharged.
Isolation		*Isolate people or the environment from the risk.* The use of bunding for containment of bulk liquid materials.
Administrative		*Provide instructions or training to people to lower the risk.* The use of Job Hazard Analysis to assess and minimise the environmental risks of an activity.
Protective		*Use of protective equipment.* Containment and recovery of spilt hydrocarbons.

Figure 5-2: Hierarchy of Controls

5.4 Determine the Impact Consequence Level and Risk Rankings (on the basis that all control measures have been implemented)

This step looks at the causal effect between the aspect/hazard and the identified receptor. Impact mechanisms and any thresholds for impacts are determined and described, using scientific literature and modelling where required. Impact thresholds for different critical life stages are also identified where relevant.

The consequence level of the impact is then determined for each planned and unplanned event using the Santos Environment Consequence Descriptors (**Appendix F**)

These detailed environmental consequence descriptions are based on the consequence of the impact to relevant receptors within the following categories:

+ Threatened/migratory/local fauna;
+ Physical environment/habitat;
+ Threatened ecological communities;
+ Protected areas; and
+ Socio-economic receptors.

This process determines a consequence level, based on set criteria for each receptor category, and takes into consideration the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem or industry level.

The level of information required to complete the impact or risk assessment depends on the nature and scale of the impact or risk. This process determines a consequence level based on set criteria for each receptor category and takes into consideration the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem or industry level. Impacts to social and economic values are also considered based on existing knowledge and feedback from stakeholder consultation. As the result of historic consultation with stakeholders, the social and economic values in the region that are of interest are evident.

As planned events are expected to occur during the activity, the likelihood of their occurrence is not considered during the risk assessment, and only a consequence level is assigned.

Table 5-2: Consequence Level Description

Consequence Level		Consequence Level Description
I	Negligible	No impact or negligible impact.
II	Minor	Detectable but insignificant change to local population, industry or ecosystem factors.
III	Moderate	Significant impact to local population, industry or ecosystem factors.
IV	Major	Major long-term effect on local population, industry or ecosystem factors.
V	Severe	Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.
VI	Critical	Irreversible impact to regional population, industry or ecosystem factors.

For unplanned events, the consequence level of the impact is combined with the likelihood of the impact occurring (**Table 5-3**) to determine a residual risk ranking using the Santos corporate risk matrix (**Table 5-4**). For oil spill events, potential impacts to environmental receptors are assessed where they occur within the EMBA using results from modelling.

Table 5-3: Likelihood Description

No.	Matrix	Description
f	Almost Certain	Occurs in almost all circumstances OR could occur *within days to weeks*
e	Likely	Occurs in most circumstances OR could occur *within weeks to months*
d	Occasional	Has occurred before in Santos OR could occur *within months to years*
c	Possible	Has occurred before in the industry OR could occur *within the next few years*
b	Unlikely	Has occurred elsewhere OR could occur *within decades*
a	Remote	Requires exceptional circumstances and is unlikely even in the long term

Table 5-4: Santos Risk Matrix

		Consequence					
		I	II	II	IV	V	VI
Likelihood	f	Low	Medium	High	Very High	Very High	Very High
	e	Low	Medium	High	High	Very High	Very High
	d	Low	Low	Medium	High	High	Very High
	c	Very Low	Low	Low	Medium	High	Very High
	b	Very Low	Very Low	Low	Low	Medium	High
	a	Very Low	Very Low	Very Low	Low	Medium	Medium

5.5 Evaluating if Impacts and Risks are ALARP

For planned and unplanned events, an ALARP assessment is undertaken to demonstrate that the standard control measures adopted reduce the impact (consequence level) or risk to ALARP. This process relies on demonstrating that further potential control measures would require a disproportionate level of cost/effort in order to reduce the level of impact or risk. If this cannot be demonstrated, then further control measures are adopted. The level of detail included within the ALARP assessment is based upon the nature and scale of the potential impact or risk. For example, more detail is required for a risk ranked as `Medium' compared to a risk ranked as `Low'.

5.5.1 Evaluating Impact and Risk Acceptability

Santos considers an impact or risk associated with the activities to be acceptable if the following criteria are met:

+ The consequence of a planned event is ranked as I or II; or a risk of impact from an unplanned event is ranked Very Low to Medium;
+ An assessment has been completed to determine whether further information or studies are required to support or validate the consequence assessment;
+ Assessment and management of risks have addressed the principles of ecologically sustainable development;
+ That the acceptable levels of impact and risks have been informed by relevant species recovery plans, threat abatement plans and conservation advice can be demonstrated;
+ Performance standards are consistent with legal and regulatory requirements;
+ Performance standards are consistent with the Santos Environment Health and Safety Policy;
+ Performance standards are consistent with industry standards and best practice guidance (e.g., National Biofouling Management Guidance Guidelines for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018));
+ Performance outcomes and standards are consistent with stakeholder expectations; and
+ Performance standards have been demonstrated to reduce the impact or risk to ALARP.

6 Environmental Assessment for Planned Events

OPGGS(E)R 2009 Requirements
Regulation 13(5)
The environment plan must include: (a) details of the environmental impacts and risks for the activity; (b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and (c) details of the control measures that will be used to reduce the impacts and risks of the activity to as low as reasonably practicable and an acceptable level.
Regulation 13(6)
To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.
Regulation 13(7)
The environment plan must: (a) set environmental performance standards for the control measures identified under paragraph (5)(c); (b) set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and (c) include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

The Santos environmental assessment identified eight potential sources of environmental impacts associated with planned events for the NV Operations. The results of the environmental assessment are summarised in **Table 6-1.** A comprehensive risk and impact assessment for each of the planned events, and subsequent control measures proposed by Santos to reduce the risk and impacts to ALARP and acceptable levels, are detailed in the following sub-sections.

Table 6-1: Summary of the residual risk associated with planned events

EP Section	Event	Consequence
6.1	Noise Emissions	I- Negligible
6.2	Light Emissions	I- Negligible
6.3	Atmospheric Emissions	I- Negligible
6.4	Seabed and Habitat Disturbance	I- Negligible
6.5	Interaction with other Marine Users	I- Negligible
6.6	Planned Operations Discharge	I- Negligible
6.7	Discharge of PW	II- Minor
6.8	Spill Response Operations	II- Minor

6.1 Noise Emissions

6.1.1 Description of Event

Event	The key potential sources of underwater noise during NV Operations include anthropogenic noise from the: + FPSO (topsides equipment, propulsion system and associated subsea infrastructure), + support vessels, + subsea IMMR activities (e.g. ROV / AUV based geophysical surveys[2]) and helicopters[3] within the operational area. Noise originating from these sources could potentially have a negative physiological or behavioural effect on marine fauna.
Extent	**Localised:** Certain frequencies from NV Operations could be audible at greater than 10 km although increases above ambient would be no greater than 4 dB and attenuate with distance.
Duration	**Permanent**: FPSO noise will be nearly constant for the field life except when the FPSO is detached from DTM buoy and out of operational area. Project vessel noise will be infrequent, as per operational requirements. Support vessel noise is approximately once every two weeks. IMMR occurs on an as per **Section 2.13**, typically for approximately 14 - 20 days in duration. Helicopter noise is infrequent occurring for shift changes or during emergency situations.

6.1.1.1 Ningaloo Vision FPSO

The mean source level SL of noise from the NV FPSO is approximately 183 dB re 1 μPa^2/HZ at 1 m in the broad frequency band (Erbe and McCauley, 2013). The maximum noise level was approximately 190 dB re 1 μPa^2/HZ. Processing equipment is mostly located on the deck, storage facilities below deck. This coupled with the double-side of the FPSO, helps insulate the marine environment from machinery noise (Erbe and McCauley, 2013).

Based on a source level of 183 dB re 1 μPa^2/HZ at 1 m it is expected that mean and maximum levels of the broadband noise produced by the FPSO would drop to the level of ambient sea noise at distance of 5.5 km.

Propeller cavitation noise is usually the loudest component of vessel noise, in particular from large and powerful vessels, such as tankers and tugs. FPSOs, unless in transit or using dynamic positioning, are quieter. The highest underwater vessel noise levels produced during the operation of FPSOs are expected to occur during the berthing of offtake tankers where multiple vessel thrusters (FPSO and offtake tanker) are in operation (Erbe *et al*., 2013) which occurs approximately on a monthly basis

6.1.1.2 Vessels

Vessels are required for NV Operations support activities and IMMR activities.

[2] IMMR occurs on an as needs basis, typically for approximately 14 - 20 days in duration

[3] crew changes for personnel onboard the FPSO will typically involve transfer by helicopter between the Ningaloo Vision and Exmouth, the nearest airport. These flights will occur typically weekly

Vessel operational noise consists of machinery noise (e.g., engine noise) and hydrodynamic noise (e.g., water flowing past the hull and propeller singing). All machinery on a ship radiates sound through the hull into the water.

For support vessels, the noisiest anticipated activity is when the vessel uses thrusters to maintain its position. McCauley (1998) measured underwater sound pressure levels equivalent to approximately 182 dB re 1 µPa @ 1 m with a frequency range of 20 Hz to 10 kHz from a support vessel holding station in the Timor Sea. The thruster noise dropped below 120 dB re 1 µPa within 3 to 4 km and was audible above ambient noise up to 20 km away (McCauley, 1998). This has been taken as the greatest noise-generating activity for assessment purposes, as other vessel activities will require the vessel to be idle or moving, e.g., IMMR activities will typically require the vessel to be moving slowly at approximately 4 knots. McCauley (1998) recorded the noise of a support vessel underway audible up to 10 km away, with the intensity dropping below 120 dB re 1 µPa at around 0.5 to 1 km away from the vessel.

6.1.1.3 IMMR Activities

The main acoustic source from AUVs and ROVs used during IMMR activities is from the thrusters, and to a limited extent from the standard fitted sonar. The sonar emits a pulse of sound (often called a 'ping') and then listens for reflections (echo) of that pulse. Typical frequency range for mounted sonar is 3 – 200 kHz and sound source levels source levels 150–235 dB re 1 uPa SPL @ 1 m (Jimenez-Arranz et al., 2017).

ROVs and AUVs may be used to conduct geophysical and inspection activities as outlined in Section 2.13, including sub-bottom profiles; MBES; SSS; cameras; and conductivity, temperature, and depth (CTD) profilers.

SBESs, MBESs and SSS are used to develop a high-resolution image of the seafloor and of objects on the seafloor such as the pipeline and subsea infrastructure. Sound pressure levels for SBESs and MBESs typically range from 210 to 245 dB re 1 µPa @ 1 m, and SSS typically range from 200–235 dB re 1µPa SPL (Jimenez-Arranz et al., 2017).

SSS is generally considered high acoustic density source and medium frequency generator. The level of sound pressure ranges from about 200–235 dB re 1µPa SPL. The frequency ranges from about 75 to 900 kHz (Jimenez-Arranz et al., 2017).

A modelling study completed in 2013 (JASCO, 2013) indicated the maximum distances at which sound pressure levels were reduced to just above background level (120 dB re 1 µPa) from different geophysical equipment types. These were:

+ MBES: approximately 1 km from the sound source;
+ SBES: approximately 350 m from the sound source; and
+ SSS: 1.5 km from the sound source.

ROV and AUV IMMR surveys will be conducted over a short duration (typically two to three weeks in duration) at a frequency determined by risk based analysis.

Reported noise emissions resulting from the use of water jetting for marine growth removal are lacking. However, Hinzmann et al (2017) report noise emissions from underwater cutting for decommissioning at 175 dB re 1 uPa PK and 150 dB re 1 µPa2.s SEL with a broadband frequency range with dominant frequency occurring between approximately 200 and 2000 Hz. The expected lower water jetting pressures required for marine growth removal compared to cutting will likely result in lower noise emissions and are therefore considered highly conservative.

6.1.1.4 Helicopters

Strong underwater sounds are detectable for only brief periods when a helicopter is directly overhead (Richardson et al. 1995). Sound emitted from helicopter operations is typically below 500 Hz and sound pressure in the water directly below a helicopter is greatest at the sea surface but diminishes quickly with depth. Reports for a Bell 214 (regarded to be one of the noisiest), indicated that noise is audible in the air for four minutes before the helicopter passed over underwater hydrophones. The helicopter was audible underwater for only 38 seconds at 3-m depth and 11 seconds at 8-m depth (Greene 1985a; cited in Richardson et al. 1995). Noise levels reported for Bell 212 helicopter during fly-over is 162 dB re 1µPa and for Sikorsky-61 is 108 dB re 1µPa at 305 m (Simmonds et al. 2004).

Helicopter engine noise is emitted at various frequencies; however, the dominant tones are generally of a low frequency below 500 Hz (Richardson et al., 1995). Sound pressure in the water directly below a helicopter is greatest at the surface and diminishes with increasing receiver depth. Noise also reduces with increasing helicopter altitude, but the duration of audibility often increases with increasing altitude, with sound penetrating water at angles < 13°. The noise from the flyover of a Bell 214 helicopter (stated to be a noisy model) has been recorded underwater (Richardson et al., 1995). The recorded broadband sound level was 109 dB re 1 µPa (SPL) when the helicopter was 152 m from the surface, with dominant frequencies below 500 Hz.

Underwater, high-frequency sounds attenuate more quickly than low-frequency sounds: a 100-Hz sound may be detectable after propagating hundreds or thousands of kms, whereas a 100-kHz sound may be detectable only for a few kms (MCC, 2007). Considering this, and reported SPL and received noise levels, noise emissions from vessels, subsea infrastructure, helicopters and IMMR activities are unlikely to occur at greater distances from the operational area compared to the continuous noise emissions from the FPSO itself.

6.1.2 Nature and Scale of Environmental Impacts

<u>Potential receptors: Cetaceans, marine turtles, fish and sharks, Plankton, pelagic/benthic invertebrates, seabirds</u>

Marine fauna use sound in a variety of functions, including social interactions, foraging, orientation, and responding to predators. Underwater noise can affect marine fauna in three main ways:

+ Injury to hearing or other organs. Hearing loss may be temporary (temporary threshold shift (TTS)) or permanent (permanent threshold shift (PTS));
+ Disturbance leading to behavioural changes or displacement of fauna. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation; and
+ Masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).

The extent of the impacts of underwater noise on marine animals will depend upon the frequency range and intensity of the noise produced, and the type of acoustic signal (i.e. continuous or impulsive).

6.1.2.1 Marine Mammals

Marine mammals that may occur within the operational area are provided in **Section 3.2.4** and include low-frequency (e.g. baleen whales), medium frequency (ondocetes e.g. orca and sperm whale) and high frequency (e.g. dolphins) cetaceans. Of these species, the humpback whale is expected to be the most frequently encountered particularly during annual migrations, given the overlap of the operational area with the migration BIA. Other species are expected to traverse the operational area infrequently. No foraging, resting or aggregating areas for any marine mammal is known to occur in the operational area or predicted extent of potential impacts from noise emissions.

The potential impacts of anthropogenic noise on marine mammals have been the subject of considerable research; reviews are provided by Richardson et al. (1995), Nowacek et al., (2007), Southall et al., (2007, 2019), Weilgart (2007) and Wright et al., (2007).

In marine mammals, the onset level and growth of TTS is frequency specific, and depends on the temporal pattern, duty cycle, and the hearing test frequency of the fatiguing stimuli. Current data and predictions show that marine mammal species differ in their hearing capabilities, in absolute hearing sensitivity, as well as frequency band of hearing (Richardson et al. 1995; Wartzok and Ketten 1999; Southall et al. 2007). To better reflect the auditory similarities between phylogenetically closely related species, but also significant differences between species groups among the marine mammals, Southall et al. (2007) assigned the extant marine mammal species to functional hearing groups based on their hearing capabilities and sound production.

Exposure to intense impulsive noise may be more hazardous to hearing than continuous (non-impulsive) noise. Impulsive sound sources include ROV sonar and SSS which are outside the auditory range of baleen whales (humpback and pygmy blue whales) but within the mid-frequency cetacean auditory range (orca, sperm whales and dolphins). The PTS and TTS thresholds (for impulsive and continuous sources) are from NMFS (2018) which is the most current technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing. These thresholds are also adopted in the more recent Southall et al. (2019) review. Southall et al (2019) also provide TTS and PTS thresholds for Sirenians (dugong). These thresholds are summarised in **Table 6-2** and **Table 6-3** and have been adopted for activities described in **Section 2**.

Behavioural reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing or physiology. Hence, it is difficult to determine thresholds for behavioural response in individual cetaceans as the way they respond often varies (Nowacek *et al.* 2004, Gomez *et al.* 2016, and Southall *et al.* 2016) and is influenced by both biological and environmental factors such as age, sex and the activity at the time. Observed disturbance responses to anthropogenic sound in cetaceans include altered swimming direction; increased swimming speed including pronounced 'startle' reactions; changes to surfacing, breathing and diving patterns; avoidance of the sound source area and other behavioural changes (NRC, 2003). The behavioural disturbance threshold criteria applied is from NMFS (2013) which is the current interim U.S. National Marine Fisheries Service (NMFS) criterion (NMFS 2013) for marine mammals and which summates the most recent scientific literature on the impacts of sound on marine mammal hearing so considered the most relevant to this activity.

Underwater noise produced by NV Operations and associated vessel operations may interfere with the ability of marine animals to detect natural sounds. This effect is termed auditory masking and has the potential to interfere with animals' communication and socialisation, the detection of predators and prey, and navigation and orientation. There is little information available regarding call masking in whales (Richardson *et al.,* 1995), although it has been suggested that an observed lengthening of calls in response to low-frequency noise in humpback whales and orcas may be a response to auditory masking (Fristrup *et al.*, 2003; Foote *et al*., 2004).

Reactions of whales to circling aircraft (fixed wing or helicopter) are sometimes conspicuous if the aircraft is below an altitude of 300 m, uncommon at 460 m and generally undetectable at 600 m (NMFS, 2001). Baleen whales sometimes dive or turn away during overflights, but sensitivity seems to vary depending on the activity of the animals. The effects on whales seem transient, and occasional overflights probably have no long-term consequences on cetaceans (NMFS, 2001). Observations by Richardson and Malme (1993) indicate that, for bowhead whales, most individuals are unlikely to react significantly to occasional single helicopter passes by low-flying helicopters ferrying personnel and equipment to offshore operations at altitudes above 150 m. Leatherwood *et al.* (1982) observed that minke whales responded to helicopters at an altitude of 230 m by changing course or slowly diving.

Table 6-2: Continuous Noise: Acoustic effects of continuous noise on marine mammals: Unweighted SPL and SEL_{24h} thresholds

Hearing Group	NMFS (2014)	NMFS (2018)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)
LF cetaceans	120	199	179
MF cetaceans		198	178

Table 6-3: Impulsive Noise: unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals

Hearing Group	NMFS (2014)	NMFS (2018)			
	Behaviour	PTS onset thresholds (received level)		TTS onset thresholds (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µP a)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224

Impacts to marine mammals are not considered significant because:

+ Impulsive noise sources are restricted to ROV mounted sonar, MBES and SSS, which emit pulses outside the auditory frequency range of baleen whales such as humpback whales, the most common species in the operational area;
+ For other marine mammal species, such as mid-frequency cetaceans and sirenians, ROV sonar and SSS impulses are only expected to exceed PTS and TTS thresholds close to the source. Due to the lack of aggregating areas for these species, individuals are expected to be transitory only, displaying behavioural responses, and moving away from the source, before TTS and PTS thresholds are exceeded;
+ Given the transitory presence of these species, and the low frequency and duration of IMMR activities, behavioural impacts to mid-frequency cetaceans and sirenians (dugongs) are expected to be temporary and at the individual level only;
+ Non-impulsive noise emission from subsea infrastructure are below behavioural, PTS and TTS thresholds for all cetacean functional groups and sirenians;
+ Noise modelling demonstrated that noise emissions from the FPSO and vessels may exceed non-impulsive TTS thresholds for cetaceans and sirenians (dugongs) within approximately 1 km of the FPSO. However, these thresholds are measures as cumulative exposure of 24 hours and given the lack of aggregating areas in the operational area or EMBA, it is not considered likely that individuals will be within the threshold range for the time period required for TTS to occur;

+ Marine mammals may show behavioural responses to continuous noise emissions from the FPSO, however, this is expected to be localised (approximately 1 km) avoidance of the FPSO. This represents a small proportion of the overall BIA width, and is unlikely to present a barrier to movement or disrupt migratory pathways or behaviour;
+ Vessel noise is expected to be below the non-impulsive (continuous) thresholds for behavioural impacts, PTS and TTS given the typical size vessels used during the NV Operations and the slow vessel speeds within the operational area;
+ Helicopter noise will be intermittent during NV Operations, and below the thresholds for PTS and TTS. Behavioural responses may be elicited and have been noted previously;
+ Reactions of cetaceans to circling aircraft (fixed wing or helicopter) are sometimes conspicuous if the aircraft is below an altitude of 300 m, uncommon at 460 m and generally undetectable at 600 m (NMFS, 2001);
+ Baleen whales sometimes dive or turn away during over-flights, but sensitivity seems to vary depending on the activity of the animals. The effects on cetaceans seem transient, and occasional over-flights probably have no long-term consequences on cetaceans;
+ Observations by Richardson and Malme (1993) indicate that, for bowhead whales, most individuals are unlikely to react significantly to occasional single-pass low-flying helicopters transporting personnel and equipment at altitudes above 150 m; and
+ Leatherwood et al. (1982) observed that minke whales responded to helicopters at an altitude of 230 m by changing course or slowly diving.

6.1.2.2 Marine Reptiles

Five species of marine turtle may occur in the operational area; flatback, green, loggerhead, hawksbill and leatherback turtles. The operational area is 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. Presence of internesting flatback turtles are unlikely, given the water depths of the area compared to measured water depths of tagged internesting turtles. Internesting habitat for the loggerhead and green turtle which are also designated a BIA, are approximately 20 km from the operational area. Transitory individuals may pass through the area.

Turtles have been shown to respond to low frequency sound, with indications that they have the highest hearing sensitivity in the frequency range 100–700 Hz (Bartol and Musick, 2003). Caged green and loggerhead sea turtles increased their swimming activity in response to an approaching airgun when the received SPL was above 166 dB re 1 µPa, and they behaved erratically when the received SPL was approximately 175 dB re 1 µPa (McCauley *et al*. 2000). Though mortality or potential mortality impacts to turtles from seismic noise exposure has not been reported, Popper *et al.* (2014) provides exposure guidelines of >207 dB PK or >210 dB SEL for impulsive sounds. Thresholds for non-impulsive (continuous) noise emissions have not been identified for marine turtles, however, playback study of diamondback terrapins (*Malaclemys terrapin terrapin*) using boat noise, some animals were observed to increase or decrease swimming speed while others did not alter their behaviour at all (Lester et al., 2013). Popper et al. (2014) identified mortality or permanent injury as being low risk to marine turtles, and TTS is moderate close to the source only.

Based on the limited data regarding noise levels that illicit a behavioral response in turtles, the lower level of 166 dB re 1 µPa level drawn from NSF (2011) is typically applied, both in Australia and by NMFS, as the threshold level at which behavioural disturbance could occur.

Turtles may be temporarily disturbed by helicopter noise if they breach the sea surface within close proximity of the FPSO when the flight height is low. At most this will be a behavioural response such a change in diving behaviour.

Impacts to marine turtles are not considered significant based on the following:

- Noise emissions from the FPSO are expected to have reduced to background levels within 5.5 km. The operational area 7 km from a internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. Considering the water depths of the operational area compared to observed water depths of internesting flatback turtles, impacts to flatback turtles are not expected at the individual or population level;
- The next closest important marine turtle habitats are the loggerhead and green turtle internesting BIAs where noise levels are expected to have reduced to background levels;
- Impulsive noise sources are restricted to ROV mounted sonar, MBES and SSS, which emit pulses outside the frequency range with highest hearing sensitivity for marine turtles;
- Following guidelines outlined in Popper et al. (2014), marine turtles are at low risk of mortality or permanent injury due to continuous noise sources, such as vessels, subsea infrastructure or the FPSO, even near the source;
- There is a moderate risk of TTS to marine turtles if they are exposed near the source, however, individuals are expected to show display behavioural response to the source, moving away and outside the range at which TTS could occur;
- Although behavioural responses are expected to occur near the sources, these will be limited to avoidance or temporary change in swimming behaviour; and
- The operational area and immediate surrounds do not represent important habitat for any marine turtle species and therefore displacement from the area, due to avoidance by individuals, is not expected to effect individual fitness or viability of the overall population.

6.1.2.3 Fish, Sharks and Rays

All fish species can detect noise sources, although hearing ranges and sensitivities vary substantially between species (Dale *et al.*, 2015). Sensitivity to sound pressure seems to be functionally correlated in fishes to the presence and absence of gas-filled chambers in the sound transduction system. These enable fishes to detect sound pressure and extend their hearing abilities to lower sound levels and higher frequencies (Ladich and Popper, 2004; Braun and Grande, 2008). Based on their morphology, Popper *et al*. (2014) classified fishes into three animal groups comprising:

- Fishes with swim bladders whose hearing does not involve the swim bladder or other gas volumes;
- Fishes whose hearing does involve a swim bladder or other gas volume; and
- Fishes without a swim bladder that can sink and settle on the substrate when inactive.

Thresholds for PTS and recoverable injury are between 207 dB PK and 213 dB PK (depending on the presence or absence of a swim bladder), and the threshold for TTS is 186 dB SEL_{cum} (Popper *et al*., 2014). Given there is no exposure criteria for sharks and rays, the same criteria are adopted, though typically sharks and rays do not possess a swim bladder.

Individual demersal fish may be impacted in the vicinity of the activity and tuna and billfish and other mobile pelagic species may transverse the operational area. However, the operational area is not known to be an important spawning or aggregation habitat for commercially caught targeted species. Therefore, no impacts to fish stocks are expected.

The criteria defined in Popper et al. (2014) for continuous (**Table 6-4**) and impulsive (**Table 6-5**) noise sources has been adopted.

Table 6-4: Continuous noise: Criteria for noise exposure for fish, adapted from Popper et al. (2014)

Potential Marine Fauna Receptor	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(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 not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(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 involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Note: Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of meters, intermediate (I) - hundreds of meters, and far (F) – thousands of meters.

Table 6-5: Impulsive noise: Criteria for noise exposure for fish, adapted from Popper et al. (2014)

Potential Marine Fauna Receptor	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{24h} or > 213 dB PK	> 216 dB SEL_{24h} or > 213 dB PK	>> 186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	>> 186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily	207 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	186 dB SEL $_{24h}$	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate

pressure detection)					
Fish eggs and fish larvae	> 210 dB SEL_{24h} or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Note: Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of meters, intermediate (I) - hundreds of meters, and far (F) – thousands of meters.

6.1.2.4 Seabirds

Plunge diving seabirds could be exposed to underwater noise emissions, however, no evidence to date has found evidence of injury due to exposure to underwater noise emissions. At most, seabird distribution may be changed indirectly through localised change in prey (fish) distribution.

Due to the distance of the FPSO location from any seabird nesting colonies (the closest area being the Muiron Islands, 40 km away), the potential for airborne noise from production activities or helicopter flights to cause disturbance to seabirds is extremely low.

6.1.2.5 Epifauna and Infauna

Seabed surveys at the Coniston/Novara and Van Gogh fields revealed a flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (**Section 3.2.2**; RPS, 2011a, Apache, 2009). The survey of the Coniston/Novara field found an infaunal community dominated by polychaetes and crustaceans and epifuana including anemones, sea stars, soft corals, crabs, shrimp and sea urchins. No unique communities or communities of particular regional significance were identified (**Section 3.2.2**; RPS, 2011a).

Although previous studies observed little effect of impulsive noise on invertebrate behaviour and population (as inferred from commercial catch rates), Day et al (2016) found evidence of behavioural responses and sub-lethal effects from repeated exposure to impulsive noise. Therefore, it is possible that a small number of individuals may present similar effects

Few marine invertebrates have sensory organs that can perceive sound pressure, but decopod crustaceans, have organs or elaborate arrays of tactile ‘hairs’, called mechanoreceptors, that are sensitive to hydroacoustic disturbances (McCauley, 1994). Close to an impulsive noise source, the mechanosensory system of many benthic crustaceans will perceive the ‘sound’ of compressed air pulses. However, for most species such stimulation would only occur within the near-field or closer, perhaps within distances of several metres from the source (McCauley, 1994).

Impacts to epifauna and infauna are considered to be insignificant at the population level since:

+ Although impacts of impulsive noise emissions to epifauna reported by Day et al., (2016) this study employed a multiple exposure method which is not a true comparison to the impulsive acoustic emissions of the IMMR ROV surveys;
+ It is possible that individuals will elicit a behavioural response during IMMR ROV survey, though in the absence of repeated exposure, and given the lack of unique or regionally significant communities, is unlikely to lead to population level effects; and
+ Impacts from continuous noise sources (e.g. subsea infrastructure) are not expected.

6.1.2.6 Plankton

No significant areas of upwelling are known to occur in the operational area. The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF is located approximately 6 km from the operational area and is the closest feature that is believed to be associated with upwelling. Seasonal peaks in zooplankton are associated with mass spawning of coral within the Ningaloo WHA (**Section 3.2.3**) 30 km from the operational area.

Impacts to zooplankton populations and broader ecosystem functioning are not expected since:

+ Lethal or sub-lethal impacts are expected to occur within close proximity of the ROV mounted sonar, MBES and SSS only;
+ IMMR ROV surveys are of low frequency and short duration; and
+ Ocean currents and mixing of the water column are expected to facilitate rapid recovery and repopulation of zooplankton in the operational area.

6.1.2.7 Areas of Ecological Significance

The Continental Slope Demersal Fish Communities KEF and humpback whale BIA are the only designated areas of ecological significance (e.g. marine parks, KEFS, BIAs) that could experience elevated noise levels due to the activities. The potential impacts are discussed above. The Ningaloo WHA is 30 km from the operational area and noise at threshold will not reach this distance and the activities will not impact the values of the WHA. For all other protected areas described in **Section 3.2.4**, noise levels are expected to have reduced to background levels and noise impacts to values and sensitivities are not expected.

6.1.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No injury or mortality to EPBC Act 1999 and WA Biodiversity Conservation Act 2016 listed fauna during operational activities [EPO-NV-01].

The control measures considered for this activity are shown in **Table 6-6**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 6-6: Control Measures Evaluation for Noise Emissions

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-01	Procedure for interacting with marine fauna	Reduces risk of physical and behavioural impacts to marine fauna from vessels and helicopters because if they are sighted, then vessels can slow down, or move away.	Operational costs to adhere to marine fauna interaction restrictions, such as vessel speed and direction.	**Adopted** – Benefits in reducing impacts to marine fauna outweigh the costs incurred by Santos. control measure ensures compliance with Part 8 of the EPBC Regulations.
Additional Control Measures				
N/A	Elimination or reduction on number of	May reduce the amount of noise emissions from vessels. Although	Elimination of vessels from the field would not achieve the Santos legal	**Rejected –** Cost disproportionate to increase in

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
	size of vessels	acoustic disturbances to marine fauna due to vessel activities are expected to be negligible as the number of vessel activities required are minimal.	requirements for petroleum production, or work-plan objectives for oil and gas production and may compromise safety standards to other marine users.	environmental benefit.
N/A	Dedicated Marine Fauna Observer (MFO) on vessels	Improved ability to spot and identify marine fauna at risk of impact from noise (that may cause harm).	Additional cost of contracting several specialist MFO	**Rejected** – Cost disproportionate to increase in environmental benefit since the fauna that could be detected by MFOs (cetaceans, turtles, whale sharks) are not expected to be impacted by the IMMR activities due to either noise emissions being largely inaudible to species (e.g. baleen whales, turtles, whale sharks), or the unlikely occurrence of individuals within the operational area (e.g. ondocetes)
N/A	Additional site-specific acoustic modelling	The distance at which fauna could experience behavioural impacts can be predicted and compared to literary publications. Additional management controls can then be included if required to support an ALARP justification and	Additional cost to contract consultant to develop a model and produce predicted noise outputs	**Rejected** — Noise emissions of the FPSO have been previously modelled (WorleyParsons, 2010). FPSO operations have not changed significantly to suggest noise emissions will differ. The cost associated with additional site-specific modelling,

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		reduce potential impacts to marine fauna.		(FPSO or other sources) outweighs any environmental benefit, and no further controls can be implemented to reduce FPSO, vessel or IMMR survey noise other than not undertaking the activity.
N/A	Noise management plan	Impacts are predicted to be minor (e.g. potential temporary and minor behavioural changes) therefore, a management plan, and associated management controls, will have little or no benefit in terms of outcomes i.e. reducing impacts further.	No additional cost to Santos other than negligible personnel costs of preparing and reviewing the management plan.	**Rejected – The** activity does not occur in a humpback whale resting, foraging or calving areas. Although noise levels may result in low level change in behaviour of migrating individuals, noise emissions are not expected to pose a barrier to migration. The cost associated with the development of a management plan outweighs the little or no benefit for a short duration activity which has a minor impact (e.g. potential temporary and minor behavioural changes).
N/A	Use of PAM during IMMR	Improve detection of some sensitive receptors.	Costs of PAM operators. Operational costs of shutdowns potentially prolonging the IMMR activity.	**Rejected -** Cost disproportionate to increase in environmental benefit given the low-level behavioural response expected. Limited ability of

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				PAM to detect baleen whales would provide little benefit to the species expected to be present.
N/A	Verification of noise levels	Allow implementation of adaptive management controls should impact be greater than expected.	Costs of deploying noise monitoring equipment and processing of data.	**Rejected –** Noise levels of the FPSO have been previously verified (WorleyParsons, 2001). FPSO operations have not changed significantly to suggest noise emissions will differ. Cost disproportionate to increase in environmental benefit given the low-level behavioural response expected.
N/A	Manage the timing of IMMR activities to avoid sensitive periods at the location (e.g. turtle internesting period; whale and whale shark migrations).	Reduce risk of impacts from noise emissions during environmentally sensitive periods for listed marine fauna (e.g. whale migrations).	Delaying IMMR activities may pose a significant risk to human health and safety, and to the environment, if activities are required to maintain integrity of the FPSO and associated infrastructure.	**Rejected** – Given the minimal risk of impacts to threatened species (e.g. whales, whale sharks and turtles) occurring, the potential risks associated with delaying IMMR activities is deemed grossly disproportionate to low environmental benefits.

6.1.4 Environmental Impact Assessment

Receptor	Consequence Level
Noise emissions	
Threatened / migratory/ local fauna	Negligible –Noise generated from the NV FPSO and associated infrastructure, vessels, helicopters and associated activities may result in short term physiological or behavioural impacts to marine fauna, especially to cetacean

	species that use sound for navigation and communication. Sensitive receptors that may be impacted include fish and sharks, cetaceans and turtles. Marine fauna potentially affected by acoustic noise are expected to exhibit temporary avoidance of the noise source. Avoidance behaviour is likely to be localised within the area of the activity (due to small spatial extent of elevated noise). Short term physiological or behavioural impacts occur to these fauna. The operational area overlaps the humpback whale migration BIA. Due to behavioural responses to noise within the operational area, humpback whales may be displaced from a small proportion of the BIA. However, the area of overall represents a small proportion of the BIA width, which is unlikely to present a barrier to movement or disrupt migratory pathways or behaviour. The main migration path during the northward migration (July to October) of the humpback whale is centred along the 200 m bathymetric contour (Jenner et al., 2001), which is unlikely to intercept the operational area where the noise emissions occur. In addition a pygmy blue whale BIA for distribution overlaps the operational area. In the Recovery Plan for Marine Turtles in Australia (DoEE, 2017) noise interference to marine turtles is separated depending on whether the exposure is short (acute) or long-term (chronic), with activities such as pile driving, seismic activity and some forms of dredging generating acute noise, and sources of chronic noise identified as including shipping channels and the operation of some oil and gas infrastructure. The operational area 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA, the water depths of the operational area compared to observed water depths of internesting flatback turtles, impacts to flatback turtles are not expected at the individual or population level. Transient individuals may exhibit behavioural responses, such as short term localised avoidance, around the NV FPSO. It is possible that whale sharks could pass through the operational area. However, the operational area does not overlap the BIA, and noise levels within the BIA are not expected to be greater than background levels. Seabirds are also unlikely to be directly affected by noise generated during the NV Operations. Due to the distance of the operational area from any seabird nesting colonies (the closest area being the Muiron Islands, 40 km away), the potential for airborne noise from production activities to cause disturbance to seabirds is Negligible.
Physical environment/ habitat	Negligible –The operational area overlaps the Continental Slope Demersal Fish Communities KEF, although habitat surveys of the Coniston/Novara fields revealed a flat soft sediment habitat comprising sand, silt and mud, and therefore fish abundance is expected to be low. It is possible that impacts to individual fish species may occur, however, the number and duration of surveys, and the expected low abundance of such species, suggests that this would be limited to short term behavioural impacts to a small number of individuals which would unlikely result in population level effects.
Threatened ecological communities	Not applicable – No threatened ecological communities identified in the area over which noise emissions are expected.
Protected areas	Not applicable – Noise levels are not expected to be greater than background levels within any protected area.

Socio-economic receptors	Negligible effects – Potential impacts to fishery resources (demersal fish species) are unlikely to result in changes in distribution and abundance of fish species outside the outside the operational area. Therefore, noise is not expected to cause an impact to socio-economic receptors.
Overall worst-case consequence level	I – Negligible

6.1.5 Demonstration of ALARP

Elimination of vessels from the field would not achieve the Santos legal requirements for petroleum production, or work-plan objectives for oil and gas production and may compromise safety standards to other marine users. Therefore, the elimination of vessels and vessel activities is not considered to be a practicable alternative on this basis.

Reducing the frequency or size of vessels is possible but would introduce disproportionate operational and safety risks; for example, the vessel is required to be of sufficient size and power to be able to efficiently and timely supply the necessities/services to maintain effective operation of the FPSO and to provide support in an emergency, e.g. man overboard or fire incidents. Similarly, reducing or removing vessel and helicopter activities, particularly during known migration periods of marine fauna, is not a viable option as these activities are necessary for the year round safe and efficient operation of the facility.

Acoustic disturbances to marine fauna due to vessel activities are expected to be negligible as the number of vessel activities required are minimal. The continued presence of various whale species in areas such as the Exmouth Basin, trafficked by commercial shipping indicates tolerance and/or habituation to ship noise within which vessel traffic would be an intermittent addition.

The sound levels generated during IMMR activities are medium to high frequency and decay rapidly with distance travelled from the source. As these activities are not within the same scale of risk that is presented by seismic activities, which operate between 10 - 300 Hz, at high intensity (215-250 dB), and have been detected over 100 km away (Swan et al., 1994), Santos do not consider that the EPBC Act Policy 2.1 (2008) Part A controls (intended for use with high risk activities) are appropriate for the scale of risk described in this EP. Furthermore, IMMR occurs on an as needs basis, and delaying may lead to unacceptable risks to human health and safety, and to the environment, if activities are required to maintain integrity of the FPSO and associated infrastructure. Therefore, scheduling of such activities outside seasonal sensitive periods for marine fauna (e.g. humpback whale migration, flatback turtle internesting) is not practicable.

Marine fauna affected in varying degrees, by acoustic noise (i.e. cetaceans, turtles, sharks and fish) are expected to avoid the source of noise. This avoidance is likely to be from a small area (due to small spatial extent of required activities) and be temporary, i.e. for the duration of the vessel activity only.

The vessels are also expected to produce similar noise emissions to other marine vessels that frequent or transit through the vicinity of the operational area (i.e. oil and gas industry vessels). All vessels will adhere to the EPBC Regulations (Part 8) which are incorporated into procedures for interacting with marine fauna to ensure that actions are undertaken to avoid cetaceans (also whale sharks) within 100 m of a vessel, and all crew members will be inducted into these requirements. It is further expected that the vessel will typically emit enough noise for sensitive marine fauna to exhibit avoidance behaviour away from the activity to avoid physical impact.

Any behavioural impact caused by helicopter or vessel noise is likely to be localised and temporary, with marine species expected to resume normal behavioural patterns in the open oceanic waters of the operational area in a short timeframe.

Maintenance and inspection of equipment is undertaken as standard and discussed in **Section 2.13.** Though maintenance activities are not conducted specifically to reduce noise, well maintained equipment will have less potential noise impact.

The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.1.3**) but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact is ALARP.

6.1.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence from noise emissions is I (Negligible).
Is further information required in the consequence assessment?	No – Potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure, which considers principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with: + Recovery Plan for Marine Turtles in Australia (2017), + Conservation Advice for Megaptera novaeangliae (humpback whale) (DoE 2015), + Conservation Management Plan for the Blue Whale, 2015-2025. Conservation Management Plan for the Southern Right Whale 2011 – 2021 Activity in accordance with EPBC approval conditions (EPBC 2007/3213). Condition 1 of the EPBC approval conditions relates to measures to reduce noise.
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this Event.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The NV Operations will result in impacts due to noise; however, with consideration of scale of the activities and elimination of the risk such as restrictions on vessel operations within proximity to cetaceans (and whale sharks), the impact is assessed as negligible.

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMP values are expected. No stakeholder concerns have been raised regarding the noise from the NV Operations.

Given the nature and scale of effects to the environment, the impacts of noise to the receiving environment are ALARP and considered environmentally acceptable.

6.2 Light Emissions

6.2.1 Description of Event

Event	Minimum lighting levels are required for safety and navigational purposes by personnel on board the NV FPSO and vessels. Lighting is used for safe illumination of the NV FPSO work and accommodation areas and of other vessels during bunkering, supply and offtake activities. Light spill can be defined as any light emitted from an artificial light source which is extraneous to that required to illuminate an object, surface or plane. Operational lighting on the NV FPSO and vessels typically consists of bright white (sodium vapour, halogen, fluorescent) lights. Other light sources on the NV FPSO consist of the flare, which has a continuously lit pilot flare for safety purposes. The flare system is provided on the NV FPSO for safe disposal of gaseous hydrocarbons. During periods that flaring is required (See **Section 2.7.4**) the NV FPSO will have an increase in light emissions. The light intensity produced by the flare during these events is a more intense light than the pilot flare. During IMMR activities, underwater lighting is generated over short periods of time during ROV use. Light from ROVs will be localised to the vicinity of the ROV in water.
Extent	**Localised**: 3–5 km from the light source during normal operations.
Duration	**Permanent**: Ningaloo Vision FPSO lighting will be constant (required 24 hours a day) for the field life except when the NV FPSO is detached from DTM and out of operational area. Support vessel presence is approximately once every two weeks. Project vessels are required less frequently, as per operational requirements.

6.2.2 Nature and Scale of Environmental Impacts

Potential receptors: Fish and sharks, marine turtles and seabirds

Artificial lighting has the potential to affect marine fauna that use visual cues for orientation, navigation, or other purposes, resulting in behavioural responses which can alter foraging and breeding activity in marine reptiles, seabirds, fish and dolphins. The species with greatest sensitivity to light are seabirds and turtles.

Potential impacts to marine fauna from artificial lighting associated with the NV Operations are:

+ Disorientation, attraction or repulsion; and
+ Disruption to natural behavioural patterns and cycles.

These potential impacts are dependent on:

+ Density and wavelength of the light and the extent to which light spills into areas that are significant for breeding and foraging;
+ Timing of overspill relative to breeding and foraging activity; and
+ Resilience of the fauna populations that are affected.

6.2.2.1 Fish

The response of fish to light emissions varies according to species and habitat. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan *et al*., 2001), with traps drawing catches from up to 90 m away (Milicich *et al*., 1992). Lindquist *et al*. (2005) concluded from a study that artificial lighting associated with offshore oil and gas activities resulted in an increased abundance of clupeids (herring and sardines) and engraulids (anchovies); these species are known to be highly photopositive. The artificial light serves to focus their marine plankton prey and consequently leads to enhanced foraging success.

6.2.2.2 Marine Reptiles (Marine turtles and sea snakes)

Marine turtles and sea snakes are two groups of marine reptiles that can occur at the within the operational area that can potentially be affected by artificial light sources. Due to the paucity of information, the direct effect of artificial light on sea snakes is largely unknown. Sea snakes may experience indirect effects such as changes in predator-prey relationships and disorientation, attraction or repulsion may occur.

The flatback turtle is one of five marine turtles known to, or likely to, occur within the operational area (loggerhead, green, leatherback, hawksbill, flatback turtles). The operational area is 7 km from a internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. It is possible that individual turtles may be encountered during NV Operations, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected.

The Recovery Plan for Marine Turtles in Australia: 2017-2027 (DoEE, 2017) highlights artificial light as one of several threats to marine turtles. Specifically, the plan indicates that artificial light may reduce the overall reproductive output of a stock, and therefore recovery of the species, by:

+ Inhibiting nesting by females;
+ Creating pools of light that attract swimming hatchlings and increase their risk of predation; and
+ Disrupting hatchling orientation and sea finding behavior.

This disruption can occur because hatchlings orient themselves to the lowest-elevation light horizon and away from high silhouettes when moving from the nest to the sea. When the direction of the lowest-elevation light horizon is not clear, hatchlings move towards the brightest, lowest horizon (Limpus & Kamrowski, 2013).

Once in the ocean, hatchlings are thought to remain close to the surface, orient by wave fronts and swim into deep offshore waters for several days to escape the more predator-filled shallow inshore waters. During this period, light spill from coastal port infrastructure and ships may ‘entrap’ hatchling swimming behaviour, reducing the success of their seaward dispersion and potentially increasing their exposure to predation via silhouetting (Salmon *et al.,* 1992).

Turtles are known to use a variety of cues for navigation when in the water. However, light is not thought to be an important cue for adults, which may move through the offshore area around the NV FPSO. Adult turtles migrating through the area may temporarily alter their normal behaviour if attracted to the light spill from the NV FPSO.

Due to the NV FPSO’s distance from the Ningaloo Coast (35 km) and Muiron Islands (40 km) and the effect of the earth’s curvature, nesting turtles and turtle hatchlings on the beaches of the mainland or islands will not see operational lighting from the NV FPSO. The WA Environmental Protection Authority (EPA) conservatively estimates there is only a light influence on marine turtles if the light source is within 1.5 km of the nesting beach (EPA, 2010). Light pollution reaching turtle nesting beaches is widely considered detrimental owing to its ability to alter important nocturnal activities, including choice of nesting sites and orientation/navigation to the sea by hatchlings (Witherington and Martin, 2003). The most significant risk posed to marine turtles from artificial lighting is the potential disorientation of hatchlings following their emergence from nests, although the behaviour of breeding adult turtles can also be affected (Rich and Long core, 2006 in EPA 2010).

Light generated by flaring events may not affect hatchlings as much as other light sources. With the most disruptive wavelengths to marine turtle hatchlings to be in the range of 300 to 500 nm. Spectral analysis of flares on Thevenard Island on the North West Shelf (Pendoley, 2000) suggests that flare light does not contain a high proportion of light wavelengths within this range.

The Recovery Plan for Marine Turtles in Australia: 2017-2027 specifies the following priority actions for the Pilbara genetic stock of flatback turtles in relation to artificial light:

+ manage artificial light from onshore and offshore sources to ensure biologically important behaviours of nesting adults and emerging/dispersing hatchlings can continue.

The potential impacts of light emissions to turtles, including flatback turtles, from the NV Operations are expected to be restricted to localised attraction and temporary disorientation to individual species transiting the operational area, no long-term or residual impact is expected. There is an unlikely presence of hatchlings within the operational area due to the distance from the nearest beaches. In addition due to the NV FPSO's distance from the Ningaloo coast mainland (35 km) and Muiron Islands (40 km) and the effect of the earth's curvature, nesting turtles and turtle hatchlings on the beaches of the mainland or islands will not see operational lighting or flare from the NV FPSO. It is considered that the activity will not compromise the objectives as set out in the marine turtle recovery plan and impact of lighting associated with the NV Operations to turtles is negligible.

6.2.2.3 Seabirds

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquenie *et al*., 2008). Light from offshore platforms has been shown to attract migrating seabirds. It is broadly accepted that seabirds do aggregate around offshore production facilities in above average numbers (Verhejen, 1985; Weise et al., 2001). This is predominantly attributed to the observation that structures in deeper water environments tend to aggregate marine life at all trophic levels, creating food sources and shelter for seabirds (Surman, 2002). The light from operating production facilities and the flare may also provide enhanced capability for seabirds to forage at night (BHP, 2005). Studies in the North Sea indicate that migratory birds are attracted to lights on offshore platforms when travelling within a radius of 3–5 km from the light source. Outside this area their migratory path will be unaffected (Marquenie et al., 2008).

The operational area is located 35 km from the Ningaloo Coast and 40 km from the Muiron Islands, both of which may provide seabird roosting or breeding habitat. Given these distances light emissions from the NV Operations are unlikely to attract and/or affect the behaviour of large numbers of seabirds. A small number of seabirds are expected to pass within the operational area whilst in transit, any behavioural disturbances such as disorientation and attraction would be minor and temporary. To date no increased seabird attraction to the NV FPSO has been observed.

6.2.2.4 Marine Mammal

There is no evidence to suggest that artificial light sources adversely affect the migratory, feeding or breeding behaviours of marine mammals. Marine mammals predominantly utilise acoustic senses to monitor their environment rather than visual sources (Simmonds et al., 2004), so light is not considered to be a significant factor in marine mammal behaviour or survival.

Marine mammals that may occur within the operational area are provided in **Section 3.2.4** and include low-frequency (e.g. baleen whales), medium frequency (ondocetes e.g. orca and sperm whale) and high frequency (e.g. dolphins) cetaceans. Of these species, the humpback whale is expected to be the most frequently encountered particularly during annual migrations, given the overlap of the operational area with the migration BIA. However, impact from light to this species is not anticipated.

6.2.3 Environmental Performance and Control Measures

The Environmental Performance Outcomes (EPO) relating to this event is:

+ Reduce impacts to marine fauna from lighting on the FPSO and support vessels through limiting lighting to that required by safety and navigational lighting requirements. [EPO-NV-02].

During the evaluation of the potential impacts of light emissions as a result of the activity, it was determined that no control measures were required as the inherent consequence of light emissions is expected to be negligible and does not compromise any recovery plans, management plans or conservation advice in place for protected fauna. Control measures considered and rejected for this activity regarding light emissions are described in **Table 6-7**.

Table 6-7: Control Measures Evaluation for Light Emissions

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-02	Lighting will be used only as required for safe work conditions and navigational purposes	Light spill from unnecessary lighting reduced, even further lowering likelihood of impacts to the environment	Additional costs associated with implementing control.	**Accepted –** Cost is considered acceptable for the benefit that may be realised from this control
NV-CM-03	Premobilisation review and planning of lighting on vessels is undertaken prior to IMMR activities commencing	Lighting is assessed to only provide necessary lighting for safety and navigation during the IMR activity, Reducing the potential for additional light pollution to the environment.	Additional costs associated with implementing control.	**Accepted –** Cost is considered appropriate for the benefit that may be realised from this control.
Additional Control Measures				
N/A	Limit or exclude night-time IMMR and vessel operations.	Reduce potential for impacts on certain sensitive receptors from light emissions during hours of darkness when light sources are more apparent and potential impacts are greatest.	High cost in moving or delaying schedule. Would at least double duration of activity given only daylight operations could occur; increase impacts or potential impacts in other areas including increase in waste, air emissions, risk of vessel collisions etc. The risk to all listed marine fauna cannot be reduced due to variability in timing of environmentally sensitive periods and unpredictable presence of some species.	**Rejected** – Given the minimal risk of impacts to listed marine species (e.g. turtles) occurring due to lighting, the financial and environmental costs of extending the activity duration are not considered appropriate given the extended duration of the activity resulting in potential impacts from other activities (e.g. discharges and physical presence) would be increased.
N/A	Review lighting to a type (colour) on	Reduce potential for impacts on certain sensitive	High cost for vessel. Potential difficulties/delays in	**Rejected** – Cost considered disproportionate

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
	vessels that has less potential to impact.	receptors from light emissions.	sourcing vessels. Potential safety/operational risks from reduced colour definition.	compared to the incremental environmental benefit. The operational area is approximately 35 km from the nearest turtle nesting beaches.
N/A	Do not flare	Reduce potential for impacts on certain sensitive receptors from light emissions.	Potential safety/operational risks	**Rejected** – Not flaring would impact the safety and viability of NV Operations

6.2.4 Environmental Impact Assessment

Receptor	Consequence Level
Light Emissions	
Threatened / migratory/ local fauna	Negligible - Sensitive receptors that may be impacted by light emissions in the same location for an extended period of time include fish at surface, marine turtles and seabirds. Light emissions may be visible to turtles transiting or internesting in surrounding areas, but unlikely to affect nesting or hatchling sea finding / dispersal activity. Given that the operational area is located >35 km from the nearest coastline / island, impacts to significant numbers of any species are unlikely. Impacts are not expected on a population level or to impact on turtle habitat. Nesting turtles and turtle hatchlings on the beaches of the mainland or islands will not see operational lighting or flare from the NV FPSO. It is possible that individual turtles may be encountered during NV Operations, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected. Cetaceans and marine mammals are not known to be significantly attracted to light sources at sea and therefore disturbance to behaviour is unlikely. Indirect impacts on food sources /habitats are also unlikely. Fish, sharks and birds have been shown to be attracted to artificial light sources, however, large scale changes in species abundance or distribution is unlikely. Impacts to transient fish, sharks and seabirds will be limited to behavioural effects with no decrease in local population size, area of occupancy of species or loss or disruption of habitat critical / disruption to the breeding cycle.
Physical environment/ habitat	Not applicable – No impacts to physical environments and/or habitats from light emissions are expected.
Threatened ecological communities	Not applicable – No threatened ecological communities identified in the area over which light emissions are expected.
Protected areas	Not applicable – No protected areas are identified in the area where planned light emissions could impact

Receptor	Consequence Level
Socio-economic receptors	Not applicable – Lighting is not expected to cause an impact to socio-economic receptors other than as a visual cue for avoidance of the area.
Overall worst-case consequence level	I – Negligible

6.2.5 Demonstration of ALARP

The presence of the NV FPSO and vessels in the field is required to undertake NV Operations. All vessels in Australian waters adhere to the navigation safety requirements Marine Order 30 – prevention of collisions navigation. Elimination or reduction of lighting onboard the FPSO or vessels would increase the potential for collision risk (and associated oil spills), introduce safety risks to marine crews and would be non-compliant with marine codes and regulations.

The lighting specification on the NV FPSO has been guided by that required for safe operation whilst minimising light intensity and light spill overboard where possible. Lights required to illuminate large areas have been directed in-board reducing light spill onto the ocean. Lights that spill overboard besides for emergency requirements are only used during vessel activities, bunkering and crude off-loading operations, which activities normally are of a limited duration. Where possible, these activities will be carried out during daylight.

No alternative lighting practices/options for the NV FPSO or vessels are considered feasible, and no additional controls to further reduce the risk of lighting disruption to marine fauna species have been identified.

Santos will consider the Commonwealth Department of the Environment and Energy's *Draft National Light Pollution Guidelines for Wildlife* as a best-practice industry standard for managing potential impacts of light pollution on marine fauna. Such lighting management controls for marine fauna will need to be balanced against marine navigation and operational safety requirements

The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.2.3**) but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact is ALARP.

6.2.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence from light emissions is I (Negligible).
Is further information required in the consequence assessment?	No – Potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure, which considers principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes –Management consistent: + International Convention of the Safety of Life at Sea (SOLAS) 1974 (FPSO) + Navigation Act 2012 (FPSO). + AMSA Marine Orders Part 30: Prevention of Collisions (vessels),

	+ Marine Orders Part 21: Safety of Navigation and Emergency Procedures (vessels) Consistent with relevant species recovery plans, conservation management plans and management actions including but not limited to: + Recovery Plan for Marine Turtles in Australia: 2017-2027 + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) Activity in accordance with EPBC approval conditions (EPBC 2007/3213). Condition 1 of the EPBC approval conditions relates to measures to reduce artificial lighting.
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this aspect.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Lighting is required for safety during the 24-hour operations and cannot be eliminated. Reduction in the lighting levels would result in non-compliance with occupational safety regulations.

The safe lighting levels were determined as part of the FPSO Safety Case assessment and is compliant with Safety of Life at Sea (SOLAS) 1974. Lighting on the vessels is designed to be at a minimum safe operational level in line with the Marine Order 30 and Marine Order 21.

The potential consequences of the anthropogenic light sources in the operational area are considered to be insignificant in nature and restricted to short-term behavioral impacts on low numbers of individual fauna that may be present in the operational area.

The operational area is located over 35 km turtle nesting beaches. At these distances light emissions will not be impact turtle hatchlings. The separation of the light sources associated with the activity from nesting beaches is consistent with the relevant actions described in the Recovery Plan for Marine Turtles in Australia: 2017-2027.

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMP values are expected. No stakeholder concerns have been raised regarding lighting for the NV Operations.

Given the nature and scale of effects to the environment, the impacts of lighting to the receiving environment are ALARP and considered environmentally acceptable.

6.3 Atmospheric Emissions

6.3.1 Description of Event

Event	Gaseous emissions to the atmosphere will be discharged during NV Operations Sources of atmospheric emissions include: + Operational flaring from the FPSO; + Combustion emissions from the FPSO (including equipment and generators), vessels and helicopters; + Waste incineration on vessels (no waste incineration occurs on the FPSO); + Fugitive emissions (non-point source emissions) on the FPSO; and + Venting of inert gas from tanks, boiler flue gas and process vents on the FPSO. The FPSO and vessels may utilise ozone-depleting substances (ODS) in closed-system rechargeable refrigeration systems. There is no plan to release ODS to the atmosphere.
Extent	**Localised**: The quantities of atmospheric emissions under normal operating conditions will quickly dissipate into the surrounding atmosphere of an open ocean environment.
Duration	**Permanent**: Throughout the duration of the 5 year environment plan and for the duration of the petroleum activities existence.

Atmospheric emissions are generated from the FPSO and support vessels during the life of the EP and duration of petroleum activities. Emissions can be continuous or intermittent and are generated from activities such as combustion, pilot flaring, operational flaring and releases (e.g. venting) and include greenhouse gases such as CO_2, CH_4, N_20, and other pollutants such as NOx, SO_2, particulates, VOCs, and refrigerants (including ozone depleting substances).

Historical emissions from NV FPSO have varied over time as can be seen in **Table 6-8** to **Table 6-11.**[4]

6.3.1.1 Operational flaring from the FPSO

The emissions generated during flaring contain water vapour, carbon dioxide, carbon monoxide, nitrogen oxides, nitrous oxides and residual unburned hydrocarbons. The quantity of emissions from the flare is the other major contributor to the total atmospheric emissions generated from the Ningaloo Vision operations.

Flaring volumes from the FPSO are heavily dependent on a number of factors and thus flaring volumes are set for varying operating conditions. Operational flaring emissions are associated with flare system purge and pilot and low and high-pressure flares. Non-routine flaring may result from activities such as shutdowns and production restarts, equipment outage/failures, process instability and subsea flowline depressurisation activities. Non-routine cold venting from the flare may result from activities such high wind events, shutdowns, and equipment outages/failures.

However, the profile may change in the future, but regardless, emissions volumes will comply with the requirements of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Safeguard Mechanism Rule).

[4] Note that values in cells shaded in pale blue simply differentiate those that are now calculated on a calendar year as opposed to a financial year.

Table 6-8: Historic Flaring Volumes and Emissions from the NV FPSO

Flaring								
Parameter	Units	FY13	FY14	FY15	FY16	FY17	FY18	FY19
Quantity	t	28,738	8,187	18,736	32,357	33,968	16,026	50,436
GHG	tCO_2-e	101,446	28,901	66,137	117,457	123,304	58,173	120,808
CO	kg	250,021	71,228	163,000	281,508	295,523	139,422	438,791
NOx	kg	43,107	12,281	28,104	48,536	50,952	24,038	75,654
TVOCs	kg	431,070	122,807	281,035	485,359	509,522	240,383	756,537
PM10	kg	1,609	458	1,049	1,812	1,902	897	2,824

6.3.1.2 Combustion emissions from the FPSO (including equipment and generators), vessels and helicopters.

Produced gas is used as the primary fuel supply on the FPSO. MDO is also used during NV Operations on the following:

+ FPSO's main engine and equipment such as for crane operation;
+ Process heating systems;
+ Essential generators; and
+ Emergency generator (used as required);

MDO is utilised as a secondary fuel source when produced gas is unavailable on the FPSO and is also used to operate engines on vessels with aviation fuel used for helicopters, within the operational area. Incinerators may be used on vessels to dispose of flammable domestic wastes such as cardboard. Wastes are generally segregated and transported to shore for disposal. There is no incinerator on the FPSO.

In the event of fuel gas shortage due to a depleting field gas cap towards the end of field life, there is the potential for increased use of MDO as a substitute for fuel gas to generate power on the FPSO. The use of MDO is challenging to the economics of the asset (e.g. significant increase in transport and purchase costs), and also presents additional environmental impacts compared to fuel gas, through increased GHG emissions, from combustion. MDO emits approximately 1.4 times more CO_2-e than natural gas on an energy basis when used for fuel. It is operationally important to delay a transition to MDO as far as possible into the future through fuel gas conservation. Fuel gas conservation efforts may include prioritisation of energy demands to operate gas compression and re-injection of the compressed gas back into the gas cap, over energy demands to operate PW reinjection (as discussed in **Section 6.7.5.5**).

As for operational flaring, the profile of combustion emissions may change in the future, but regardless, emissions volumes will comply with the requirements of the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Safeguard Mechanism Rule).

Table 6-9 and **Table 6-10** present the historic fuel gas and other combustion emissions.

Table 6-9: Historic Fuel Gas Volumes and Emissions from the NV FPSO

Fuel Gas								
Parameter	Units	FY13	FY14	FY15	FY16	FY17	FY18	FY19
Quantity	t	56,608	30,738	9,665	69,090	52,814	56,179	66,279

GHG	tCO_2-e	153,322	83,252	25,268	187,858	144,905	154,139	177,011
CO	kg	159,610	86,666	27,251	194,803	150,262	159,838	181,072
NOx	kg	615,637	334,285	105,110	751,385	579,582	616,518	707,666
TVOCs	kg	4,028	2,187	688	4,916	3,792	4,034	4,645
PM10	kg	3,648	1,981	623	4,453	3,435	3,653	4,199

Table 6-10: Historic Other Combustion Volumes and Emissions from the NV FPSO

Other combustion								
Parameter	**Units**	**FY13**	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**
GHG	tCO_2-e	22,844	16,652	15,452	6,449	6,202	5,118	4,679
CO	kg	358,290	87,887	81,538	33,687	32,392	26,731	32,629
NOx	kg	1,381,285	338,824	314,346	129,870	124,880	103,055	125,792
TVOCs	kg	43,462	10,663	9,893	4,087	3,930	3,243	3,959
PM10	kg	50,251	12,327	11,436	4,725	4,543	3,749	4,576

6.3.1.3 Fugitive emissions (non-point source emissions) on the FPSO

Fugitive emissions are generally those resulting from minor leaks across components, such as pipe connections, valves, rotating shafts and other equipment. The majority of fugitive emissions are hydrocarbon gases. Relative to combustion emissions, fugitive emissions are insignificant. **Table 6-11** presents the historic fugitive and other emissions volumes and emissions. Note: The fugitives are un-combusted hydrocarbon gases so they only have a greenhouse and a volatile organic compound quantity shown in **Table 6-11** and no carbon monoxide, NOx, SOx or particulates which are associated with combusted fuels.

Table 6-11: Historic Fugitive and Other Emissions Volumes and Emissions from the NV FPSO

Fugitives / other emissions								
Parameter	**Units**	**FY13**	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**
GHG	tCO_2-e	1,236	553	240	,574	933	747	1,116

6.3.1.4 Venting of inert gas from tanks, boiler flue gas and process vents on the FPSO.

Crude storage tanks are blanketed with inert gas which is continuously vented during the loading of oil in the cargo tanks of the FPSO. The gas vented during filling and holding of the tanks is a combination of inert gas and hydrocarbon gas at atmospheric pressure as the oil weathers. Venting rates vary with diurnal effects and loading/unloading periods. Vented gas, which is primarily nitrogen, is generated as a result of the inert gas system. Non-routine cold venting from the flare may result from activities such high wind events, shutdowns, and equipment outages/failures but are over short durations. Non-routine cold venting from the flare may result from activities such high wind events, shutdowns, and equipment outages/failures but are over short durations.

6.3.2 Nature and Scale of Environmental Impacts

Potential Receptors: Seabirds and humans

Atmospheric emissions generated from the NV Operations have the potential to result in a localised, temporary reduction in air quality. Emissions generated (combustion) and released (e.g. venting) include CO_2, CH_4, N_2O NOx, SO_2, methane, particulates, and VOCs. Incomplete combustion under certain scenarios may also generate dark smoke, these can lead to a reduction in local air quality which can impact humans and birds in the immediate vicinity of release. The emission of GHGs (CO_2, CH_4 and N_2O) contributes incrementally to Australian greenhouse emissions. Atmospheric emissions from these sources will, under normal circumstances, be quickly dispersed into the surrounding atmosphere.

The operational area is in a remote offshore location, with no expected adverse interaction with populated areas or sensitive environmental receptors associated with air emissions. There are no nearby human receptors such as townships within 30km. There are no resident bird populations within the operational area. Transiting birds rarely reside on the NV FPSO for a length of time that would significantly expose them to reduced air quality conditions.

Potential impacts are expected to be short-term, and relate to localised reduction in air quality, limited to the immediate vicinity of the emissions release. Atmospheric emission impacts are not expected to have direct or cumulative impacts on sensitive environmental receptors or be above National Environmental Protection (Ambient Air Quality) measures.

The flare and potential associated smoke or haze at times can be a negative visual aesthetic. However, given the distance of the operational area to the nearest shoreline (>35 km) it is not anticipated that it will be seen and no impact to tourism or resident communities is anticipated.

In addition, Global greenhouse gas (GHG) generated by the NV Facility are reported annually under the NGER Scheme. Data publish by NGER (2019) demonstrates that oil & gas activities contribute significantly less to state and country-wide GHG emissions than electricity supply and mining industries. As such, the primary action (i.e. operation of the Ningaloo Vision facility) does not constitute a 'substantial case; of the circumstance (climate change). Impacts to climate from production operations emissions will be localised and will quickly dissipate on completion of flaring or venting events. Any impacts will be minor in nature.

6.3.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ Reduce impacts to air and water quality from planned discharges and emissions from operational activities [EPO-NV-03].

The control measures considered for this activity are shown in **Table 6-12**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 6-12: Control Measures Evaluation for Atmospheric Emissions

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-04	FPSO Planned Maintenance System and class certification system	Reduces emissions because equipment is maintained and operating within its parameters.	Operational costs and labour/access requirements of undertaking maintenance.	**Adopted -** Benefits of operating equipment within operational parameters will help control emissions created by equipment.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
NV-CM-05	Vessels Planned Maintenance System	Reduces emissions from vessels because equipment is operating within its parameters.	Operational costs and labour/access requirements of undertaking vessels maintenance.	**Adopted -** Benefits of operating equipment within operational parameters will help control emissions created by equipment.
NV-CM-06	Fuel oil quality	Reduces emissions through use of low sulphur fuel on vessels and FPSO in accordance with Marine Order 97.	Operational costs of refuelling.	**Adopted** - Environmental benefit outweighs cost and it's a legislated requirement.
NV-CM-07	Vessels Air Pollution Prevention Certificate (IAPP)	Reduces probability of potential impacts to air quality due to ODS emissions, high NOx, SOx and incineration emissions.	Personnel cost of ensuring vessel has current international IAPP certificate, during vessel contracting procedure and in pre-mobilisation audits/ inspections.	**Adopted** - Benefits of ensuring vessel is compliant outweighs the minimal costs and it's a legislated requirement.
NV-CM-08	Ozone depleting substance (ODS) handling procedures	Reduces probability of potential impacts to air quality due to ODS emissions.	Personnel cost of maintaining ODS record book/recording system.	**Adopted** - Benefits of ensuring no ODS release outweighs the minimal costs
NV-CM-09	Vessel waste incineration management	Reduces the potential for emissions/ particulates by ensuring only permissible waste is incinerated as per Marine Order 97.	Personnel cost of maintaining waste records and training of staff.	**Adopted** – Benefit to air quality outweighs the costs associated with transporting waste to shore for landfill.
NV-CM-10	Power generation system fuel	Primary fuel used on FPSO is produced gas. This reduces the	No cost, produced gas is utilised from the	**Adopted** – Benefit to air quality

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		need for diesel use and reduces associated atmospheric emissions.	NV operations gas recovery.	outweighs the minimal costs
NV-CM-11	National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015	The safeguard mechanism provides a framework for Australia's largest emitters to measure, report and manage their emissions. It does this by encouraging large facilities, whose net emissions exceed the safeguard threshold, to keep emissions compliant with the requirements set by the Clean Energy Regulator.	Costs associated with operational optimisation to meet requirements of the Rule.	**Adopted –** Legislated requirement.
NV-CM-12	Emissions Reporting required by the Clean Energy Regulator through the National Greenhouse and Energy Reporting (NGERS)	Enables collection of emissions data through a single national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption and production to meet the objectives and desired outcomes of the legislation such as: + the maintenance and improvement of air and water quality, minimisation of environmental impacts associated with hazardous wastes; and an	Administrative costs of recording and collating information and reports to the Clean Energy Regulator by 31 October each year.	**Adopted - –** Legislated requirement.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		improvement in the sustainable use of resources; and + act as the single framework to inform policy, meet reporting requirements, avoid duplication, and ensure that net greenhouse gas emissions from the facility are managed within applicable baselines.		
NV-CM-13	National Pollution Inventory (NPI) Reporting	Collects information about emissions across Australia.	Administrative costs of recording and collating information and reports	**Adopted -** – Legislated requirement.
Additional Control Measures				
N/A	No incineration of waste on vessels	Eliminate the potential for emissions due to waste incineration to impact air quality	Increase in health risk from storage of wastes. Increase in risk due to transfers (increased fuel usage, potential increase in collision risk, disposal on land).	**Rejected** – Health and safety risks outweigh the benefit given the offshore location. Cost associated with transporting waste to shore for landfill and/or incineration outweighs on-board incineration
N/A	Removal of all ODS containing equipment.	Eliminates potential of ODS emissions occurring, impacting on air quality	Lack of refrigeration systems on-board the vessels would lead to unacceptable	**Rejected** – Based on cost to replace all equipment and there is only a low potential for ODS releases.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			workplace conditions (i.e. air conditioning) and poor food hygiene standards, limiting the vessels' ability to undertake the activity, therefore there is no practical solution to the use of refrigeration. It is noted that ODS is rarely found on vessels.	
N/A	Alternative fuel type (non-hydrocarbon based) selected for all vessels and helicopters.	Could reduce level of pollutants released to the environment during fuel combustion	Practical and reliable alternative fuel types and power sources for the helicopters and vessels has not been identified. If an alternative was available, vessels have fuel specification for equipment, change of fuel may require further modifications to equipment.	**Rejected –** Not feasible.
N/A	Vessels to use incinerators and engines with higher environmental efficiency	Improves air quality by more efficient burning or fuel combustion	Significant cost in changing unknown vessel equipment	**Rejected -** Cost grossly disproportionate to low environmental benefit (impact rated negligible)
N/A	Eliminate flaring by venting uncombusted hydrocarbons instead	Not further assessed as flaring occurs for the majority of operational time and is a key safety critical element for the safe	Not further assessed as flaring is a key safety critical element for the	**Rejected** – Long term sustained operational hydrocarbon venting is not good industry

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		operation of the FPSO.	safe operation of the FPSO.	practice, as unburnt hydrocarbons pose potential for greater environment impact compared to combusted emissions. In addition, the ability to flare hydrocarbons is a key critical safety element for the safety operation of the FPSO. Removing the ability to flare hydrocarbons may result in unacceptable safety risks on the FPSO.

6.3.4 Environmental Impact Assessment

Overall, the emissions present a negligible impact to the when compared with the Australian or global contribution. The main greenhouse gas impacts associated with the operational activities at the NV operational area are:

- the contribution to global warming via release of greenhouse emission to the atmosphere; and
- Associated air quality issues resulting from other combustion by-products (e.g. NOx and SOx), and the potential for visual amenity impacts from aspects such as dark smoke.

Receptor	Consequence Level
Atmospheric Emissions	
Threatened / migratory/ local fauna	Negligible - Short-term behavioural impacts to seabirds could be expected if bird overfly the release location; as they may avoid the area. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle / introduction of disease.
Physical environment/ habitat	No reduction in physical environment/ habitat area or function is expected.
Threatened ecological communities	Not applicable –these receptors will not be impacted by air emissions.
Protected areas	
Socio-economic receptors	The operational area is within offshore waters, the combustion of fuels, and flaring will not impact on air quality in coastal towns. The quantities of

Receptor	Consequence Level
	gaseous emissions will, under normal circumstances, quickly dissipate into the surrounding atmosphere. The highly dispersive nature of local winds (i.e. strong and consistent) is expected to reduce potentially harmful or 'noticeable' gaseous concentrations within a short distance from the operational area and therefore not impact on other marine users in the vicinity.
Overall worst-case consequence level	I – Negligible

6.3.5 Demonstration of ALARP

Vessel presence and operation is required to undertake the production activities. Atmospheric emissions from hydrocarbon combustion for vessel use in Australian waters are permissible under the Marine Order 97.

The use of low sulphur fuel rather than intermediate or heavy fuel oil contributes a significant reduction in potential impacts, reducing the carbon content of combustion emissions and the extent of any local particulate and haze effects. No further changes in fuel are technologically viable for the available vessels and all helicopters used for the NV Operations operate on the same type of aviation fuel. Instead, risk and impact reduction can be further achieved through planned maintenance providing for clean and efficient operation of engines for efficient combustion of fuel. Practicable, reliable and cost effective alternate fuel types for the FPSO, helicopters and vessels have not been identified.

Alternative options considered, such as replacing the main gas compressors with two variable speed electric motor driven centrifugal compressors have been rejected due to reduced sparing capacity posing a risk to production and cost implication, which is grossly disproportionate to the environmental benefit.

Lack of refrigeration systems (i.e. air conditioning) on board the FPSO and vessels would lead to unacceptable workplace conditions and poor food hygiene standards, limiting the ability to undertake the NV Operations, therefore there is no practical alternative to the use of refrigeration.

Compliance with the requirements of the Safeguard Mechanism Rule will ensure the facility is managed so that the emissions comply with the baseline which represents the reference point against which emissions performance will be measured (nothing that a baseline may be adjusted to accommodate economic growth or natural resource availability) under the safeguard mechanism.

The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.3.2**) but rejected since the associated cost / effort was grossly disproportionate to any potential environmental benefit. It is considered therefore that the impact is ALARP.

6.3.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence from atmospheric emissions is I (Negligible).
Is further information required in the consequence assessment?	No – Potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure, which considers principles of ecologically sustainable development.

Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with: + Pursuant to Marine Order 97 (vessels) and MARPOL Annex VI (FPSO). Activity in accordance with EPBC approval conditions **(**EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – A query was raised by Cape Conservation Group as outlined in **Table 4-2** which was addressed. Control measures and associated environment performance standards are included (**Section 6.7.3** and **Table 8-2**) Risks and impacts are considered consistent with stakeholder expectations.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Atmospheric emissions from vessels are permissible under the Marine Orders 97 (vessels) and MARPOL Annex VI (in accordance with FPSO class certification). The fuel oil utilised during the NV Operations will be MARPOL compliant in order to control emission quality.

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMP values are expected. No stakeholder concerns directly specific to the revised 5- year EP have been raised regarding atmospheric emissions for the NV Operations.

Given the nature and scale of effects to the environment, the impacts of atmospheric emissions to the receiving environment are ALARP and considered environmentally acceptable.

6.4 Seabed and Benthic Habitat Disturbance

6.4.1 Description of Event

Event	The following IMMR activities (as detailed in **Section 2.13**) will cause minor disturbance to the seabed within the operational area: + Post cyclone surveys requiring the use of an ROV; + Subsea infrastructure inspection and cleaning requiring the use of an ROV; + Cleaning requiring marine growth removal which leads to resuspension of sediment; removal of marine biota; + Replacement, maintenance and repair of subsea equipment components requiring the use of an ROV; + Stabilisation of subsea infrastructure requiring the placement of material such as grout / gravel bags or mattresses on the seabed; and + The replacement of umbilicals and other subsea infrastructure. Note, the risk of accidental introduction of marine pest species that may be released through the removal of marine growth is described in **Section 7.1.**
Extent	**Localised:** within the operational area. Stabilisation of subsea infrastructure requiring placement of material (grout / gravel bags, mattresses etc) and replacement of umbilicals are likely to have the greatest potential to

	disturb the seabed. Generally, these activities are restricted to relatively localised areas, directly underneath or beside, or nearby to existing infrastructure within the operational area. ROV use, placement of ROV tooling baskets and removal of marine growth may cause minor localised seabed disturbance.
Duration	**Infrequent**. Seabed disturbance will continue throughout the life of the field on an as required and on a planned basis. Some disturbance is permanent in the case that subsea infrastructure is required to be replaced or span rectification materials are placed on the seabed.

6.4.2 Nature and Scale of Environmental Impacts

Potential Receptors: Benthic habitats

The following impacts are predicted from seabed disturbance:

+ Direct physical disturbance of an area of seabed habitat;
+ Indirect disturbance to benthic habitats and associated marine fauna by sedimentation or the near-seabed water column; and
+ Increased turbidity of the near-seabed water column.

6.4.2.1 Benthic habitat disturbance

The seabed of the operational area is unconsolidated sediments, comprising of sand, silt and mud (**Section 3.2.2**). The depth of the operational area (approximately 340-400 m) precludes the existence of benthic primary producers (i.e. photosynthetic organisms including hard corals, seagrasses and macroalgae), as seabed light availability at these depths is insufficient to support photosynthesis.

Disturbance to bare sediment habitat from placement of materials (including replacement of sections of flowlines/umbilicals, jumpers etc) and ROV operation / tooling placement will have a localised disturbance to infauna and epifauna which could result in epifauna removal or localised decrease in abundance and diversity of infauna. However, such disturbance will have no impact at an ecosystem or population level. Any turbidity generated would be momentary and is not predicted to impact water column or benthic fauna given the deep water in an open ocean environment. Material is placed in localised areas in the proximity of the subsea infrastructure and usually over areas of previous disturbance (e.g. within the flowline corridor). Given the localised disturbance (see **Section 6.4.1**) coupled with the fact that previous surveys have not identified any sensitive seabed habitats impacts to benthic habitat are considered minor.

The Continental Slope Demersal Fish Communities KEFs occurs within the operational area. This KEF covers a large area where demersal fish endemism and diversity is high. With the exception of the subsea infrastructure itself, which will act as an artificial habitat for benthic invertebrates and fishes, there are no seabed features (e.g., reefs, canyons, shipwrecks) present within the operational area that would be expected to aggregate demersal fishes. Any localised disturbance to benthic habitat is not expected to have an impact to any fishes attracted to the subsea infrastructure, although localised and temporary avoidance or attraction could occur during ROV IMMR operations.

Disturbance of the seabed associated with commercial fisheries that target benthic fauna (i.e. North West Shelf Trawl Fishery), which targets primarily scampi, is possible. However, there is no current fishing effort recorded in the vicinity of NV Operations and the expected area of disturbance within the operational area has no potential to impact fisheries since fishing is not permitted in the area.

6.4.2.2 Turbidity and Sediment Quality

A temporary reduction in water and sediment quality may occur due to increased turbidity and increased sediment deposition during IMMR activities such as those requiring placement of materials (e.g. new flowline section, span rectification material etc.) and / or the placement of the ROV / ROV tooling baskets on the seabed. Placement of materials on the seabed may result in a localised and temporary plume of suspended sediment over the area of seabed disturbance. Sediment within the plume will subsequently settle on the seabed after a period in the water column. Localised areas of the seabed and associated biota may be affected, however given the expected nature and scale of turbidity resulting from IMMR activities and the small footprint of such material (see **Section 6.4.1**), impacts such smothering or burial are not expected as a result of turbidity and no impact is expected from a temporary localised reduction in water quality.

6.4.2.3 Artificial habitat creation

The presence of the FPSO, DTM mooring points and subsea infrastructure and any materials placed on the seabed (such as replaced flowlines or gravel bags / concrete mattresses) has the potential to act as artificial habitat or hard substrate for the settlement of marine organisms that would not otherwise be successful in colonising the area. Over time the colonisation of this infrastructure can lead to the development of a ‘fouling’ community, which subsequently provides predator or prey refuges, foraging resources for pelagic fish species and artificial reefs potentially supporting fish aggregations (Galloway et al., 1981). The depth of the subsea infrastructure on the seabed (approximately 340 - 400 m) precludes the development of hard coral reefs as light availability at these depths is insufficient to support photosynthesis.

The FPSO hull is painted with a non-tin based anti-fouling coating in accordance with the International Convention on the Control of Harmful Anti-fouling Systems on Ships to reduce marine growth on the hull and toxic effects to the marine environment (e.g. no Tributyltin [TBT] is used in the paint). As the seabed infrastructure is not painted with an antifouling coating but located in water depth of over 340m, little marine growth is associated with the infrastructure on the seabed.

It is not intended to remove antifouling paint during in-water inspection and maintenance work; however, the removal of ‘fouling’ growth that is required to carry out the inspections and maintenance activity may remove some paint flakes attached to the base of marine organisms and be dispersed in the ocean. This may lead to a short term, localised release of anti-fouling paint. The release into the marine environment will have a negligible impact upon the plankton, invertebrates and fish inhabiting the water column due to the localised scale and small quantity of disturbance, the infrequent requirement of in-water inspections.

There is also potential for the paint flakes to be deposited on the seabed where they would remain in the sediments before degradation through chemical and biological processes. However, the quantity of anti-fouling paint flakes being accumulated would be extremely low and sparse spatially, thereby preventing chemical concentrations (fouling leachates) reaching levels sufficient to cause detectable environmental impacts on benthic fauna.

6.4.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ Seabed disturbance is limited to the operational area [EPO-NV-04].

The control measures considered for this activity are shown in **Table 6-13**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 6-13: Control Measures Evaluation for Seabed and Benthic Habitat Disturbance

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-14	Dropped object prevention controls	Implementation of a dropped object prevention controls for equipment deployment, helps to protect integrity of infrastructure on the seabed and equipment being lowered. This in turn minimises impacts and extent of seabed disturbance through sediment suspension impact.	No additional costs to Santos other than negligible personnel costs of reviewing information and implementing.	**Adopted** – Helps to protect integrity of infrastructure on the seabed and equipment being lowered which in turn minimises impacts and extent of seabed disturbance.
NV-CM-15	Dropped object recovery	Requires dropped objects to be recovered (where safe and practicable to do so).	Additional personnel and vessel costs to plan and undertake if safe and practicable to do so.	**Adopted -** Benefits of recovering dropped objects where safe and practicable to do so outweighs the costs.
Additional Control Measures				
N/A	Elimination of IMMR activities	No seabed or habitat disturbance from IMMR activities.	It may potentially result in more severe environmental impacts (e.g., a hydrocarbon leak) and compromising with the safety requirements from the approved Safety Case.	**Rejected –** Increased (transferred) risk disproportionate to environmental benefit.

6.4.4 Environmental Impact Assessment

Receptor	Consequence Level
Seabed and habitat disturbance	
Threatened / migratory/ local fauna	Negligible - No sensitive seabed features are expected within the operational area. The areas of seabed that will be impacted are expected to be un-vegetated and likely to have sparse benthic and epi-benthic communities with low biodiversity (refer to **Section 3.2.2**) and include species with widespread regional distributions. Therefore significant loss of habitat is not expected.

	Marine invertebrates may inhabit soft sediments and can contribute to the diet of some fauna. The area of soft sediment habitat that is potentially impacted is small compared to the amount of habitat available and therefore the disturbance is not expected to affect prey availability, and therefore protected fauna species. Habitat modification is identified as a potential threat to a number of marine fauna species in relevant Recovery Plans and Conservation Advice (**Table 3-8**). Impacts will be temporary and the area potentially impacted is small compared to the size of the areas used by species for foraging. Therefore no long-term impacts to these species are expected. No decrease in local population size, area of occupancy of species, loss or disruption of critical habitat or disruption to the breeding cycle of any threatened / migratory/ local fauna is expected.
Physical environment/ habitat	Negligible –The operational area overlaps the Continental Slope Demersal Fish Communities KEF, although habitat surveys of the Coniston/Novara fields revealed a flat soft sediment habitat comprising sand, silt and mud, and therefore fish abundance is expected to be low Long-term or significant impacts to habitat values or ecosystem function are not expected.
Threatened ecological communities	Not applicable – No threatened ecological communities identified in the area over which seabed disturbance. are expected.
Protected areas	Not applicable – No protected areas are identified in the operational area where seabed disturbance could occur.
Socio-economic receptors	No stakeholder concerns have been raised regarding this event.
Overall worst-case consequence level	I– Negligible

6.4.5 Demonstration of ALARP

Seabed disturbance cannot be eliminated. Elimination of IMMR activities may potentially result in more severe environmental impacts (e.g., a hydrocarbon leak) and compromise the safety requirements within the approved FPSO Safety Case.

Seabed disturbance associated with the will be limited IMMR activities requiring placement of materials (e.g. new flowline section, span rectification material etc.) and / or the ROV / ROV tooling baskets on the seabed. The disturbance will involve an area of benthic habitats (i.e. primarily soft sediments with little epifauna) that are widely represented at a regional scale on the NWS. Given the relatively small area of disturbance (see **Section 6.4.1**, extent), the impacts are not considered to be significant. The vessels will be DP and no anchoring is planned within the operational area, further reducing potential impacts to the benthic environment.

The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.4.3**) but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact is ALARP.

6.4.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum seabed disturbance consequence is I (Negligible).

Is further information required in the consequence assessment?	No – Potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure, which considers principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – No plans identified seabed disturbance as those described above as being a threat to marine fauna or habitats. Habitat modification is identified as a potential threat to a number of marine fauna species in relevant Recovery Plans and Conservation Advice (**Table 3-8**). Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this event.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

NV Operations will result in some level of seabed disturbance; however, with consideration of the control measures in place, the impact is assessed as negligible.

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMP values are expected. No stakeholder concerns have been raised regarding the seabed disturbance from the NV Operations.

Given the nature and scale of effects to the environment, the impacts of seabed disturbance to the receiving environment are ALARP and considered environmentally acceptable.

6.5 Interaction with Other Marine Users

6.5.1 Description of Event

Event	A 500 m radius gazetted petroleum safety zone (PSZ) extends around the DTM buoy and will be maintained, including when the FPSO is not within the operational area. Vessels associated with the NV Operations may undertake activities (e.g. IMMR activities) within the PSZ and operational area at any time. All vessels, except for the vessels and tankers associated with the NV Operations, will be required to stay outside the PSZ. Implementation of the PSZ excludes other users from a small area of the sea. This PSZ arrangement and the recurring presence of vessels and offtake tankers within the operational area may potentially result displacement of other users of the water, such as commercial fishers and shipping traffic. As described in **Section 2.5.1.1**, the FPSO may disconnect and reconnect to the DTM buoy for cyclone avoidance, to leave the field for maintenance activities (e.g. shipyard campaigns) or in the event of cessation of operations (**Section 2.16**). To allow for the pick-up and reconnection of the DTM when the FPSO has an intention to return, a floating pickup line arrangement is left attached to the DTM.

	Under a steady current stream when the FPSO is disconnected, this pick-up line arrangement can extend to approximately 500m in length (made up of three lengths of cow hitched floating marine line/DTM lifting line) and poses a potential risk to other marine users.
Extent	**Localised:** The operational area.
Duration	**Permanent**: Interaction and displacement of other marine users from the operational area for the duration of field life. Support vessel presence is approximately once every two weeks. Project vessels are required less frequently, as per operational requirements.

6.5.2 Nature and Scale of Environmental Impacts

Potential Receptors: marine user groups, commercial fishers, shipping traffic and other oil and gas activities

The presence of the 500 m PSZ which extends around the DTM buoy potentially impacts on commercial and recreational fisheries in ways such as:

+ loss of fishing area through displacement; and
+ target fish species being attracted to the NV FPSO and infrastructure and away from nearby fishing areas due to the presence of artificial habitat and associated marine communities and additional food sources.

The extent and intensity of commercial and recreational fishing in the vicinity of the operational area is very low, and the impacts on fisheries from a 500m PSZ are not likely to be realised. Since NV Operations began, there have been no recorded interactions with commercial or recreational fishing vessels.

The presence of the NV FPSO and the 500 m PSZ may be an obstacle for shipping traffic in the region. These impacts may include a loss of access to the area, navigational hazards and a collision risk. The potential impact of the loss of shipping access to the small area of the safety exclusion is considered negligible as the main shipping route is located 40 km to the north west of the NV FPSO location, and the PSZ has been in force since the FPSO entered the field and has not resulted in any adverse shipping impacts. Should vessels need to deviate from planned routes to avoid the 500 m PSZ, it is unlikely to increase transit times and fuel consumption.

A 2.5 nm cautionary zone extends around the subsea infrastructure, however the third party vessels are permitted to anchor, transit and or fish as long as it is safe to do so within this zone.

Tourism activities are not expected to occur in the operational area given the water depths (>340 m) and distance from shore (35 km north-northwest Ningaloo coast), impacts to tourism from planned activities are therefore not expected.

Based on the distances between the NV FPSO and other operating or proposed FPSOs (the nearest being 4 km to the south), there is unlikely to be any impact to the operations of other petroleum companies (e.g. tanker movement restrictions).

As described in **Section 2.5.1.1**, the FPSO may disconnect and reconnect to the DTM buoy for cyclone avoidance or to leave the field for maintenance activities (e.g. shipyard campaigns) or in the event of cessation of operations (**Section 2.16**). To allow for the pick-up and reconnection of the DTM when the

FPSO returns from a temporary departure of the field, a floating pickup line arrangement of approximately 500m is left attached to the DTM for reconnection purposes. This pick up line arrangement could pose a potential vessel prop/fouling issue if a vessel was to enter than 500m safety exclusion zone around the DTM.

6.5.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ Reduce impacts on other marine users through the provision of information to relevant stakeholders such that they are able to plan for their activities and avoid unexpected interference [EPO-NV-05].

The control measures considered for this activity are shown in **Table 6-14**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 6-14: Control Measures Evaluation for Interaction with Other Users

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km, is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-17	Navigational charting of infrastructure	Subsea infrastructure is charted on Australian AHS Nautical Charts so other users are aware	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – The positive benefits of identifying subsea infrastructure to other marine users outweighs the process of arranging their

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				charting with AHS.
NV-CM-18	Navigation lighting and aids	Reduces risk of environmental impact from vessel collisions due to ensuring safety requirements are fulfilled and other marine users are aware of the presence of the FPSO and vessels.	Negligible costs of operating and maintaining navigational equipment.	**Adopted** – Benefits considered to outweigh negligible costs.
NV-CM-19	Seafarer Certification	Requires appropriately trained and competent vessel personnel, in accordance with Marine Order 70, to navigate vessels to reduce interaction with other marine users.	Costs associated with personnel time in obtaining qualifications.	**Adopted** - Benefits considered to outweigh costs and is a legislated requirement.
NV-CM-20	Stakeholder consultation	Santos will update relevant stakeholders on a quarterly basis on the operations. All external stakeholder communications are recorded in a database. Stakeholder concerns with vessel presence can be addressed.	Costs associated with personnel time in preparing and distributing information and collating/addressing any feedback provided.	**Adopted** – Benefits considered to outweigh negligible costs to Santos
NV-CM-21	Notification to AHO and JRCC prior to commencement of vessel based IMMR activities	Santos will require vessels contractors notify AHO and JRCC prior to any vessel based IMMR activity	Minor cost associated with personnel making notification	**Adopted** – Benefits considered to outweigh negligible costs to Santos

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		commencement. Will make others aware of vessels presence.		
NV-CM-22	DTM pick up line arrangement attachment management, when the FPSO is off station for + longer term absences such as shipyard campaigns, or + if the FPSO is permanently off station.	Limiting the length of the pickup line arrangement from the DTM when the FPSO is off station for extended periods of time, reduces the risk of interference with other vessels (not withstanding they should not be within the 500m safety exclusion zone around the DTM buoy) and also reduces potential for entanglement with marine fauna.	Organisational costs associated with vessel to limit the length of attachment (rope or otherwise) from the DTM buoy	**Adopted** – Benefits considered to outweigh negligible costs to Santos
NV-CM-23	Add a float/buoy to the DTM pick-up line arrangement when FPSO off station for longer term absences (e.g. shipyard campaigns).	With a float/buoy attached, the rope arrangement streams in direction of the prevailing current/wind conditions. This streaming effect reduces the potential for the rope to become entangled on itself creating a 'bird-nest'. It is considered that a tangled rope on the sea surface is a higher risk of whale entanglement compared to a single strand.	Organizational and logistics costs associated with enabling the support vessel to attach the float/buoy to the pickup line arrangement.	**Adopted** – Benefits considered to outweigh negligible costs to Santos

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		Although not intended to be a navigational hazard marker, it will also provide a visual cue to other marine users who inadvertently enter the 500m PSZ.		
Additional Control Measures				
N/A	Reducing the PSZ	Reduces the area of displacement of other marine users	The PSZ is mandated by the OPGGS Act and cannot be reduced.	**Rejected** OPGGS Act requires PSZ is in place around the DTM buoy.
NA	Limiting the length of the pickup line arrangement when the FPSO is leaving the field for cyclone avoidance	The length of floating rope on sea surface is reduced resulting in reduction of the hazard associated with whale entanglement and interference with other marine users.	Costs and safety issues associated with having a support vessel to limit the pickup line arrangement length, whilst trying to assist the FPSO to safely get off location, as well as avoid impending cyclone itself.	**Rejected** Costs and safety issues outweigh the environmental benefit to be gained It is a safety critical requirement that the FPSO and support vessel can leave the field quickly, efficiently and safely.
N/A	Complete removal of the DTM pickup line arrangement every time FPSO is off location.	Removes the hazard interference with other marine users.	Removal of the entire DTM pick-up line cannot be done using an ROV due to the type of fixings which are used to attach it to the DTM. Attachment of the rope to the DTM is a mechanical process only possible with hand operated tools. Thus, it could only be done by saturation divers.	**Rejected** Costs, safety risk and the removal of the ability to undertake hook-up maintenance activities on the DTM while the NV is off station, outweigh the environmental benefit.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			Cost of mobilising a vessel equipped for saturation diving to remove and reattach the pick-up line is estimated to be $1M. This control also removes the ability to undertake cost-effective maintenance activities on the DTM while NV is off station as the presence of the rope allows a smaller less expensive vessel (non- DP) to perform ROV integrity inspections on the DTM while the NV is off station. If the pick-up line is not present then any vessel-based maintenance activities which did occur would be required to be completed under Dynamic Positioning (DP). Typical cost differential of $250 – 500K depending on scope and duration.	
N/A	Installation of a Navigational Hazard Marker Buoy on the DTM pick-up line arrangement	Increases the visibility of the PSZ and indicates to other marine users that there are navigational hazards within the area (i.e. the DTM pick-up line arrangement).	Navigational markers are significantly larger than the surface float/buoy that is being installed on the DTM pick-up line and may pose more of a risk of damage to smaller vessels. It is also considered that damage to the equipment located at the top of the DTM is possible due to loads	**Rejected:** The navigational hazard marker buoy adds no additional benefit than the buoy/float. A navigational buoy will also not remove the need to have the DTM pick-up line arrangement in place for when

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			on the line during storm and cyclonic events. An assessment of effects associated with the drag caused by a large navigational marker attached to the DTM during a storm or cyclonic event has not been undertaken. This would require additional personnel and engineering costs to assess whether the DTM could be damaged by a navigational marker during a storm or cyclonic event.	FPSO returns to location.

6.5.4 Environmental Impact Assessment

Receptor	Consequence Level
Interaction with other users	
Threatened / migratory/ local fauna	Not applicable – consequence related to socio-economic receptors only.
Physical environment/ habitat	
Threatened ecological communities	
Protected areas	
Socio-economic receptors	Negligible - Given that the FPSO has been operational since 2010 with shipping vessels required to deviate slightly around it since this date, the impacts to shipping are considered to be negligible due to the small area affected in comparison to the area available for vessels to navigate through. In addition, the distance from the operational area to the nearest main shipping route is 40 km to the north west. The extent and intensity of commercial and recreational fishing in the vicinity of operational area is very low, the impacts on fisheries are not likely to be realised.

Receptor	Consequence Level
	The open waters in the vicinity of the operational area do not support significant recreational or tourist activity and therefore impact to recreational fisheries or tourism is not expected.
Overall worst-case consequence level	I – Negligible

6.5.5 Demonstration of ALARP

The risk of interfering with other users of the sea will be reduced to ALARP by informing stakeholders of the ongoing activities, implementing navigation controls and maintaining communications.

Relevant stakeholders are updated on a quarterly basis, as described in **Section 4** so they are informed and aware of the any NV Operations relevant to them.

Efforts made to limit the extent of the DTM pick up line arrangement helps to avoid and reduce impacts on other marine users should they inadvertently enter then 500m safety exclusion zone around the DTM location which is also marked on Australian Hydrographic Charts. The implementation of this existing control ensures that other marine users are made aware of/reminded of the exclusion zone, which reduces the potential for impacts to subsea infrastructure by third party operators, further contributing to the ALARP.

For times when the FPSO is off station for extended periods of time (e.g. shipyard) risks are reduced through the limiting the length of the line and also the installation of a buoy as a visual sea surface reminder.

If the FPSO is to leave the site permanently, then the pickup line arrangement will be limited even further as the length is not required to reconnect the FPSO (noting that it cannot be removed completely as explained in the controls evaluation in **Section 6.7.3**). The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.5.3)** but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact is ALARP.

6.5.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence from physical impacts is I (Negligible).
Is further information required in the consequence assessment?	No – Potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with: + International Convention of the Safety of Life at Sea (SOLAS) 1974 (FPSO) + Navigation Act 2012 (FPSO). + Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) + AMSA Marine Orders Part 30: Prevention of Collisions (vessels)

	+ Marine Orders Part 21: Safety of Navigation and Emergency Procedures (vessels) Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this event.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The NV FPSO has been operational and on navigational charts since 2010 with shipping vessels required to deviate slightly around it since this date.

A 500m PSZ around the DTM buoy is required under maritime legislation, and the controls proposed will ensure that other users are aware of its presence and readily able to navigate accordingly, such that potential impacts are ALARP and are considered to be acceptable.

No stakeholder concerns have been raised regarding interaction with other users from the NV Operations.

Given the nature and scale of effects to the other users, the impacts of physical presence are ALARP and considered environmentally acceptable.

6.6 Planned Operations Discharge

6.6.1 Description of Event

Event	Planned discharges into the marine environment within the operational area will include the following: Near-surface discharges: + Sewage and grey water disposal; + Putrescible waste disposal; + Desalination brine disposal; + Cooling water disposal; + Boiler blowdown water; + Deck drainage disposal; + Bilge water disposal; + Firefighting AFFF from routine testing. Near-seabed chemical and fluid discharges: + Treated seawater discharges from subsea infrastructure (may include MEG) + Methanol discharges from subsea infrastructure (during IMMR or commissioning) + Water based hydraulic fluid / subsea control fluids + Inorganic and Organic acids (used during IMMR or commissioning) Residual hydrocarbon and inert gas may also be discharged during IMMR activities such as changeouts/replacements of subsea infrastructure or commissioning.

	Under circumstances described in **Section 2.7.5,** PW may be discharged to the marine environment once processed through the PW treatment system. PW discharge is discussed in **Section 6.7.**
Extent	**Localised**: All discharges within the operational area will disperse quickly in surface waters given the high energy offshore environment.
Duration	**Permanent**: Ongoing but intermittent throughout the life of field. Support vessel presence is approximately once every two weeks. Project vessels are required less frequently, as per operational requirements.

6.6.1.1 Sewage and grey water disposal

The volume of sewage and grey water is generated on the FPSO and vessels and is directly proportional to the number of persons on-board. Up to 30-40 L of sewage/greywater will be generally be generated per person per day on vessels.

The sewage treatment plant (STP) on the NV has a capacity to treat up to 22.5m^3 liquids/day (80 people). The daily volume of treated sewage and grey water discharged overboard is approximately 10,000 L based on a 50 POB the FPSO during normal production and a wastewater generation rate of 200 L/person/day (based on average water consumption of 10 m^3/day). The STP is operated as per Sewage Treatment Plan Operation (NV-91-IP-10027).

6.6.1.2 Putrescible waste disposal

Food scraps are generated on the NV FPSO and vessels (approximately 1 L of food waste per person per day). The scraps are macerated and discharged within the operational area as permitted under the Marine Order requirements.

6.6.1.3 Desalination brine disposal

Fresh water for boiler feed and domestic use is produced in freshwater generators installed in the NV FPSO engine room. The generators convert seawater to fresh water with resulting brine which is discharged to the ocean. The generator uses a seawater feed supply of approximately 800 m^3 per day and produces around 28m^3 of fresh water per day. The maximum overboard brine discharge from the NV FPSO is 788 m^3 per day at approximately 1.04 times seawater salt concentration.

The Reverse Osmosis (RO) system on the NV FPSO uses a seawater feed supply of 190 m^3 per day and produces 45 m^3 of fresh water. The overboard brine discharge is approximately 145 m^3 per day at approximately 1.3 times seawater salt concentration.

The desalination of seawater results in a discharge of seawater with a slightly elevated salinity (4-30% higher than seawater). On average, seawater has a salt concentration of 35,000 mg/l, while the desalination discharge has a salt concentration in the range of about 36,000-45,000 mg/l dependant on the system used. The volume of the desalination brine discharge is dependent on the requirement for fresh (or potable) water which averages about 34m^3/d.

Volumes of desalination brine from vessels are difficult to quantify, as they vary based on the number of people on board each vessel and their time on location. However, the salinity concentration will be similar.

6.6.1.4 Cooling water discharge

Seawater is used as a heat exchange medium for the cooling of machinery engines and in the production process. On the NV FPSO, seawater is drawn from the ocean and flows counter current through closed-circuit heat exchangers, transferring heat from the machinery or production process to the seawater. Cooling water is discharged from the NV FPSO both on a continuous and on an intermittent basis. The maximum discharge from the continuous sources is approximately 8,000 m^3/hr (approximately 192,000 m^3/day). The design temperatures for the cooling system water is between 35°C to 45°C, however thermal imaging of cooling water discharges conducted have indicated that discharge temperatures are 10-14°C less than design temperatures (APASA, 2010).

There are no chemical additives added to the seawater cooling water that is discharged to the marine environment.

Cooling water discharge locations, flow rates and discharge temperatures are presented in **Table 6-15**. An assessment of the cooling water discharge parameters modelled in 2010 and the current discharge parameters showed no substantial change, therefore modelling results from 2010 have been determined applicable to the current discharge.

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Table 6-15: Summary of Cooling Water Discharges and Modelling Parameters

Discharge Locations	Note	Flow rate (m^3/hr)	Temp (degrees)	Distance from mid ship (m)	Depth of discharge (m)	Pipe diameter (mm)	Included in modelling (APASA, 2010)
D1: Atmospheric Condenser (200 mm)	-	350	37	-103	-5	200	Yes
D3: LPSG Seawater blowdown (40 mm) -	20 minutes per-day	15	100	-103	-5	40	Yes
D25: Main Seawater Cooling (300 mm)	-	450	37	-92	-5	300	Yes
D11: Aux Condenser Cool water (400 mm)	-	610	37	-71	-5	400	Yes
D29: TA Vacuum Condensers (2 x 600 mm)	-	2300	37	-40	2	2 x 600	Yes
D30: Gas Compression Modules (150 mm)	-	200	37	55	2	150	Yes
D31/D32: Oil Cooler, Injection Water Cooler, & PW Flotation Unit	-	2500	37	-5	2	2 x 300	Yes
D22: Air-conditioning refrigeration condenser(150mm)	-	340	37	-80	-5	150	Yes
DXX: Orca 60 FW Maker Discharge (65mm)	-	14	37	-100	-5+	65	No – Minor volume
D27: Atlas FW Maker Discharge (65mm)	-	14	37	-100	-5	65	No – Minor volume
Steam Condensate Cooler Discharge (150mm)	-	14	45	-40	2	65	No – Minor volume

6.6.1.5 Boiler and low-pressure steam generator (LPSG) blowdown water

Boiler and low-pressure steam generator (LPSG) blowdown water is generated from the two deck boilers and a LPSG that provide steam for the main turbine generators, process and tank heating and for freshwater generators. The boiler water is treated with a small quantity of boiler chemicals (oxygen depleter, sludge conditioner and alkalinity controller) that are consumed during the water treatment process. Discharge is below the water line at <150°C and at a reduced pressure. Approximately 3 m^3 to 5 m^3 of blowdown water per day is discharged for from the boilers the LPSG over a 15-20 minute period.

6.6.1.6 Deck drainage disposal

Under normal operating conditions, scupper plugs are fitted at open deck drainage points on the FPSO to direct drainage to the dirty slops tank. If clean water builds up after for example heavy rain these plugs are manually removed allowing the clean water to drain to sea. Deck drainage may contain small residual quantities of oil, control fluid, grease and detergents from leaks from engines, machinery, fresh or waste oil drums and residual cleaning agents if present on the decks following clean-up.

Deck drainage on offtake tankers is managed according to the OCIMF and the International Safety Guide for Oil Tankers and Terminals (ISGOTT) guidelines to prevent discharge of oily water.

Vessels may also discharge drainage water from decks directly overboard in a similar fashion to the FPSO, however in much lower volumes.

6.6.1.7 Bilge water discharge

The FPSO bilge water is routed to slops tank system and following processing through the produced water system is discharged with PW (refer **Section 6.7**). Oily filtration residue (sludge) separated in the treatment system will be collected in a dedicated onboard tank and will be disposed of onshore.

Vessels routinely generate and discharge relatively small volumes of bilge water. Bilge tanks receive fluids from parts of the vessel, including machinery spaces. Bilge water can contain water, oil, dispersants, detergents, solvents, chemicals, particles and other liquids, solids or chemicals.

6.6.1.8 Fire Fighting Foam

During routine testing of each area covered by the AFFF firefighting system, approximately 500 L of AFFF will be discharged from the foam tanks. It is unavoidable that some of this foam will be discharged to sea as follows:

The majority of AFFF will be captured in the closed bunding system (main deck and chemical injection storage area) or drained to the marine environment. The helideck and turret areas (moonpool) will drain to the marine environment by design.

6.6.1.9 Subsea hydraulic fluid

Subsea control fluid is used to control valves (e.g. control wellhead valves on the subsea Xmas trees). A water based hydraulic fluid is typically used and is supplied to valves via an open-loop system, designed to release fluid during operation (e.g. upon valve actuation).

Volumes of approximately 2.5 L of hydraulic control fluid are typically discharged during each 120 mm (5-inch) valve closure or opening on the four subsea manifolds and 0.016 L for each choke valve step actuation. It is estimated that a maximum of approximately 80-100 L per day of hydraulic control fluid may be discharged to the marine environment if control valves were operated daily (not normally the case).

6.6.1.10 Treated seawater discharge

Treated seawater may be discharged during activities such as flushing (typically in a MEG 80/20 mix) during subsea infrastructure disconnect activities and during replacement of subsea infrastructure. It may include a biocide, oxygen scavenger, corrosion inhibitor and non-toxic dye. The subsea infrastructure will be depressurised before any open flushing activities so will not be under pressure. Flushing of subsea infrastructure would typically only release < 1m^3 per line for any minor flushing activity.

6.6.1.11 Methanol discharges from subsea infrastructure

Methanol may be used for IMMR activities which involve replacement, maintenance and repair of subsea equipment components and during commissioning activities. Methanol may be used to displace gas within subsea infrastructure prior to disconnection and change out activities and during pressure testing (e.g. validate gas pressure of subsea infrastructure such as Gas Lift Jumper's (GLJ), during leak off testing (LOT)). In these scenarios it is estimated that any discharge to the ocean would be typically <1 m^3. Leak testing of subsea system may also occur in which case a small volume (estimated at <5 L) of non-toxic dye may also be used to assist in the visual detection of leaks in the subsea system by ROV. Typically, these discharges are infrequent and restricted to those needed to complete a required task.

6.6.1.12 Inorganic and Organic acids

Inorganic or Organic acids may be required during IMMR activities, for tasks such as cleaning, approximately 1000 L per operation (e.g. per soak for marine growth removal) and is released to the deep ocean open marine environment.

6.6.1.13 Residual hydrocarbon and /or inert gas (methane)

During IMMR activities such as changeouts/replacements and commissioning activities, residual hydrocarbon and / or inert gas may be present in the subsea equipment and be discharged to the sea after it is isolated and disconnected from the subsea system. The isolated equipment will be at ambient seabed pressure and therefore any residual hydrocarbon and / or inert gas will be displaced through natural seawater ingress into the equipment, which will displace the residual gas bubble from the equipment.

6.6.2 Nature and Scale of Environmental Impacts

Potential Receptors: Fish (pelagic) & sharks, marine mammals, marine turtles and seabirds

6.6.2.1 Sewage, greywater and food scrap discharge

The routine discharges of sewage, greywater and food scrap from the FPSO and vessels could result in localised increases in nutrient concentrations, exert Biological Oxygen Demand (BOD) on the receiving waters and may promote localised elevated levels of phytoplankton and bacteria activity due to nutrient inputs. Dispersion and dilution of discharges from the FPSO and vessels are expected to be rapid as the operational area is located in deep offshore waters (> 300 m) dominated by swift currents, resulting in short-term changes to surface water quality within the operational area. In addition, vessels are typically moving when in the operational area, which facilitates the mixing of sewage, putrescible wastes and grey water from vessels.

Sewage discharge studies (Friligos, 1985) demonstrate a rapid uptake of nutrients and/or rapid dispersion in the surrounding waters of the discharge location. Nutrient inputs from facilities on the NWS are likely to be quickly taken up given the high-water column productivity, as shown by Furnas and Mitchell (1998) for the Harriet Alpha platform, suggesting elevated nutrients will be very localised. Somerville *et al.* (1987) (as cited in Swan *et al*., 1994), showed that there is little likelihood that sewage discharges in offshore, well-mixed waters will result in oxygen depletion of receiving waters.

Some fish and oceanic seabirds may be attracted to the FPSO by the discharge of food scraps. This attraction may be either direct, in response to increased food availability, or secondary as a result of prey species being attracted to the facilities. However, given the small quantities, intermittent nature of disposal and swift currents, any attraction is likely to be minor and is not expected to result in adverse impacts at an ecosystem or population level.

The impact of nutrients associated with discharge of sewage, grey-water and putrescible waste is considered to have a localised impact immediate vicinity of the release. No significant or lasting impact is anticipated due to the highly dispersive waters within the operational area and the extent of the water column (water depth >340 m).

6.6.2.2 Desalination brine discharge

Desalination brine may have increased salinity of up to 1.3 times seawater concentration and contain low treatment chemicals. Desalination brine is discharged from the same side (port side) of the NV FPSO as the cooling water and makes up <1% of the discharge occurring from that side. Given the low volume the discharge is unlikely to have an impact upon sensitive receptors. Most marine species are able to tolerate short-term fluctuations in salinity, in the order of 20% to 30 (Walker and McComb, 1990), and it is expected that most pelagic species passing through the operational area would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine.

6.6.2.3 Cooling water discharge

Cooling water makes up the largest portion of discharge from the FPSO. The potential impacts arising from discharge of cooling water include:

+ Thermal impacts to marine organisms; and
+ Decline in water quality associated with lowered dissolved oxygen concentrations as a result of elevated water temperature.

Modelling of the water temperature impacts from cooling water discharges at the FPSO was conducted by APASA (2010). This modelling investigated the increase above ambient seawater temperature that would be caused by the combined cooling water discharges from the FPSO and took into consideration turbulent nearfield mixing and farfield mixing of cooling water driven by prevailing environmental conditions (i.e. sea temperature, wave action and surface currents). The modelling considered historical environmental data from three years (2004, 2005 and 2008) over three seasons (summer, winter and transition).

The main conclusions from the of the cooling water discharge temperature modelling were:

+ Within 50 m from the FPSO a sea temperature increase of 2°C is predicted to occur less than 25% of the time;
+ The discharge plumes are predicted to drift west to southwest most of the time, corresponding with the high frequency of west to southwest currents throughout the year at the FPSO location;
+ The greatest distance away from the FPSO that a 2°C rise in temperature was found to occur was 300 m in winter (1% of the time), 250 m in transition season (1% of time) and 150 m in summer (1% of the time);
+ Winter has the largest temperature differences to ambient due to a combination of low ambient water temperatures, relatively low current magnitudes and the persistence of the current direction towards the south-west; and
+ These water temperature increases are within the range of temperatures experienced on the NWS and naturally occurring organisms in the area would likely be tolerant of such increases.

Elevated seawater temperatures are known to cause alteration of the physiological processes (especially enzyme-mediated processes) of exposed biota (Wolanski, 1994). These alterations may cause a variety of effects, ranging from behavioural response (including attraction and avoidance behaviour), to minor stress, to potential mortality for prolonged exposure.

Organisms utilising surface waters include plankton, fish, marine turtles, marine mammals and seabirds. Fish and plankton are likely to be at greatest risk from cooling water discharge impacts since they are most likely to be attracted to the discharge location (fish) or entrained within the discharge plume (plankton). Fish and plankton are also relatively small, cold blooded organisms that may experience increased body temperature and altered physiological processes (e.g. increased respiration rate and oxygen demand). However, given that the area of raised water temperature will be highly localised and within the range of temperature on the NWS significant impacts on a larger ecosystem or population level to fish or plankton are not expected to occur.

Given the localised impacts in water quality from the discharge and the lack of any natural seabed features that would indicate a high abundance or diversity of demersal fishes within the operational area, it is believed that discharges would have a negligible impact on the demersal fish populations of the Continental Slope Demersal Fish Communities KEF.

Black *et al*. (1994) suggests that cooling water discharges has detrimental effects on plankton that become entrained in the cooling water plume but that the impact is likely to be localised, which is supported by Wolanski (1994). Phytoplankton photosynthesis may increase or decrease, and the breeding patterns of various invertebrates can change (Black *et al*., 1994).

Turtles, seabirds or marine mammals may come in contact with the cooling water discharge for a short period should the transit through the operational area. In addition, the operational area overlaps with the pygmy blue whale distribution BIA and a migration BIA for humpback whale. However, the operational area is not known harbour significant numbers of these species and any visits of these fauna to the operational area would likely be temporary only and prolonged negative impacts from raised water temperature are not expected.

6.6.2.4 Boiler and LPSG blowdown water

Due to the short duration (15-20 min) and relatively insignificant volumes (3 to 5 m^3) of boiler blowdown discharges with respect to the overall continuous cooling water discharges it is not expected that noticeable increase in water temperature would occur within the operational area over and above that of cooling water discharges (described above), despite the higher discharge temperature of the blowdown water (<150°C). Given the low volumes of water discharged and the highly dispersive marine environment within the operational area, potential impacts to marine sensitive receptors from the blow down water and any additives are expected to be negligible.

6.6.2.5 Deck drainage and bilge water

Discharge of contaminated deck drainage and bilge water (from vessels only) into the marine environment may result in a temporary water quality reduction and adversely impact marine fauna and flora through the contact with surface hydrocarbon concentrations <15 ppm. Within the operational area, dispersion and dilution is expected to be rapid, resulting in short-term localised changes in water quality.

6.6.2.6 AFFF

The AFFF products (1%, 3% and 3% AR) have been assessed using the *Operations Chemical Selection Evaluation and Approval Procedure* (EA-91-II-10001).

Water quality changes are expected to be localised and temporary due to the dispersive nature (strong currents and winds) of the marine environment within the operational area and any consequences are expected to be negligible.

6.6.2.7 Near-seabed chemical and fluid discharges:

On discharge to the marine environment, the small volumes of chemicals (such as MEG, non-toxic dyes, methanol and organic acids) are expected to rapidly disperse in the offshore marine environment. Hence, any potential impacts would be confined to a highly localised area immediately surrounding the release location near the seabed. The potential impacts of hydraulic fluid discharges near the seabed are a localised reduction in water quality and potential toxicity to benthic marine fauna associated with bare sediments or attracted/attached to subsea infrastructure (e.g. fish, infauna and sessile filter feeding organisms).

There may be a localised and temporary (hours) reduction in water quality in the immediate vicinity of the release. Toxicity impacts to the marine environment from the release of chemicals and hydraulic fluids are unlikely to eventuate because:

+ The chemicals and hydraulic fluids will have been risk assessed for their suitability for discharge using *Operations Chemical Selection Evaluation and Approval Procedure* (EA-91-II-10001) (**Section 2.8.9.3** and be selected for low toxicity and bioaccumulation potential;
+ The low sensitivity of the receiving environment;
+ Relatively small volumes of discharges;
+ Strong ocean currents mean that the discharge will become further diluted upon discharge, so the duration of exposure of chemicals to fauna will be minimal; and
+ Potential discharges will be localised, intermittent and temporary within the operational area.

The benthic habitat in the operational area is predominately unconsolidated sediments, comprising sand, silt and mud. Sub-lethal or lethal effects to infauna from chemicals / fluids discharged near the seabed, is considered unlikely given the expected low concentrations and short exposure times. It is believed that discharges would have a negligible impact on the demersal fish populations of the Continental Slope Demersal Fish Communities KEF.

Refer to the PW risk assessment (**Section 6.7)** for an assessment of the impacts of chemicals discharged with FPW.

6.6.2.8 Residual hydrocarbon and /or inert gas

Residual hydrocarbon and /or inert gas (methane) is not readily water soluble and so will not saturate the water column, instead rising rapidly to release to the atmosphere at the sea surface rather than being trapped at depth in the water column. The gas is not persistent on the surface.

Studies on the impacts of methane on fish have shown that a behavioural response can be elicited through continuous exposure such as increased activity and scattering within the water (avoidance behaviour). Continuous exposure at high concentrations can lead to toxic impacts but is dependent on the exposure time, environmental conditions and the nature of the toxicant.

The discharge of residual gas will be small (typically less than 10 kg) and is not expected to impact any marine fauna other than potentially inciting avoidance behaviour.

6.6.3 Environmental Performance and Control Measure

The Environmental Performance Outcome (EPO) relating to this event is:

+ Reduce impacts to air and water quality from planned discharges and emissions from operational activities [EPO-NV-03].

The control measures considered for this activity are shown in **Table 6-16**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 6-16: Control Measures Evaluation for Planned Operational Discharges

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-24	Sewage system	Reduces potential impacts of inappropriate discharge of sewage on FPSO and vessels. Ensures compliance with Marine Order 96 requirements.	Personnel cost in ensuring vessel certificates are in place during vessel contracting and in pre-mobilisation audits and inspections, and in reporting discharge levels.	**Adopted** – Benefits of ensuring and maintaining compliance outweigh the costs.
NV-CM-25	Oily mixture system	Reduces potential impacts of planned discharge of oily water to the environment. Ensures compliance with Marine Order 91.	Time and personnel costs in maintaining oil record book.	**Adopted** – Benefits of ensuring and maintaining compliance outweigh the costs.
NV-CM-26	NV FPSO deck drain system and bunding	Reduces the likelihood of any oily/chemical content reaching the marine environment, from the NV FPSO.	Personnel and operational costs associated with construction and maintenance of offshore bunding and maintenance of bunding procedure.	**Adopted** – Benefit of the inspection to determine operational integrity outweigh the cost to undertake the inspection.
NV-CM-27	Garbage management	Reduces probability of garbage being discharged to sea from NV FPSO and vessels, reducing potential impacts to marine fauna. Stipulates putrescible (food) waste disposal conditions and limitations. Ensures compliance with Marine Orders 95 requirements.	Personnel cost of pre-mobilisation audits and inspections, and in reporting discharge levels.	**Adopted** – Benefits of ensuring and maintaining compliance outweigh the costs.
NV-CM-28	Deck cleaning product selection	Improves water quality discharge (reduce toxicity) to	Personnel costs of implementing. Potential additional	**Adopted** – Benefits of ensuring vessels

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		the marine environment. Those deck cleaning products planned to be released to sea meet the criteria for not being harmful to the marine environment according to MARPOL Annex II.	cost and delays of deck cleaning product substitution.	are compliant and those deck cleaning products planned to be released to sea meet MARPOL criteria.
NV-CM-29	Chemical selection procedure	Aids in the process of chemical management that reduces the impact of liquid discharges to sea. Only environmentally acceptable products are used.	Cost associated with implementation of procedure. Range of chemicals reduced with potentially higher costs for alternative products.	**Adopted** – Environmental benefit of using lower toxicity chemicals outweigh procedural implementation costs.
Additional Control Measures				
N/A	Reduce, capture or eliminate use of chemicals and hydraulic fluid	Would eliminate or reduce the chemical and hydraulic fluid discharge to the marine environment.	Chemicals are assessed to ensure the discharge is environmentally acceptable in accordance with Operations Chemical Selection Evaluation and Approval Procedure (EA-91-II-10001). Excessive use of chemicals is restricted. Eliminating the use of chemicals and hydraulic fluid would cause safety and process issues.	**Rejected** – Safety and process considerations outweigh the environmental benefit given small volumes and low toxicity of the discharges.
N/A	Do not test AFFF containing fire fighting equipment on the FPSO	Would eliminate the discharge of the small quantities of AFFF.	Increased safety risk due to potentially untested AFFF system. Inability to fight fire effectively.	**Rejected** – Safety considerations outweigh the environmental benefit given

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				small volumes and low toxicity of the discharges.
N/A	Scupper plugs on vessels and NV FPSO are continuously in place to prevent deck drainage.	Would eliminate potential impacts of contaminants being discharged to sea from deck water.	Increased health and safety risks from wet deck not draining. Large amounts of water on a vessel and FPSO deck can also cause stability issues (free-surface effect). Storage space required for containment of drained liquids, increase in transfers to vessels resulting in increased potential impacts and risks. Increased transfers result in increased fuel usage, increased safety risks to personnel during transfer (e.g. crushing between skips), increase in crane movements.	**Rejected** – Safety considerations outweigh the environmental benefit given small volumes of contaminants. Deck drainage is a permitted maritime practice and an important safety requirement.
N/A	Zero discharge of sewage from NV FPSO and vessels	Would eliminate potential impacts of contaminants being discharged to sea from sewage.	Costs associated with containment and onshore disposal, space required for additional containment on NV FPSO and vessels could create hazards for working on deck by limiting available space.	**Rejected** – Safety considerations regarding containment outweigh the environmental benefit given small volumes of contaminants. Discharge of treated sewage to sea is permitted maritime practice.
N/A	Zero discharge of bilge water from vessels	Would eliminate potential impacts of contaminants being discharged to sea from oily water.	Costs associated with containment and onshore disposal, space required for additional containment on vessels could create hazards for working on deck by limiting available space.	**Rejected** – Safety considerations regarding containment outweigh the environmental benefit given small volumes of contaminants. Discharge of treated oily water to sea is

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				permitted maritime practice.
N/A	Discharge point for cooling water discharges, restricted to above sea level to allow it to cool further before mixing at sea surface.	Potential to discharge cooling water above sea surface to aid in cooling process.	High costs associated with modifications to FPSO and vessels. Reduction in temperature would be minimal compared to significant cost of altering the discharge height.	**Rejected** – Cost grossly disproportionate to environmental benefit. Limited benefit to be gained given low impact. Discharge of cooling water permitted maritime practice.
N/A	Zero discharge of cooling water on NV FPSO and vessels	Would eliminate potential impacts of cooling water (elevated temperature) being discharged to sea.	Costs associated with containment and onshore disposal, space required for additional containment on FPSO and vessels could create hazards for working on deck by limiting available space. Technically not an available option given volumes of cooling water required to be stored	**Rejected** – Cost grossly disproportionate to environmental benefit. Limited benefit to be gained given low impact. Discharge of cooling water permitted maritime practice.
N/A	Restrict use of desalination on NV FPSO and vessels	Would eliminate potential impacts from brine discharges by importing potable water.	Cost associated with transporting potable water. Health risks associated with limited supply of potable water.	**Rejected** – Cost grossly disproportionate to environmental benefit. Limited benefit to be gained given low impact. No detectable change in water quality expected. Water-making and brine discharge permitted maritime practice.
N/A	Zero discharge of putrescible waste from NV FPSO and vessels	Would eliminate potential impacts from putrescible waste discharges by storing on-board for onshore disposal.	Cost associated with transporting putrescible waste to shore, space required for additional containment on vessels could create hazards for working on	**Rejected** – Cost grossly disproportionate to environmental benefit. Limited benefit to be gained given low impact. Health

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			deck by limiting available space. Health risks and costs associated with storage on-board and transport/disposal onshore.	risks associated with managing putrescible waste in hot weather conditions, putrescible waste discharge is a permitted maritime practice.
N/A	Use of subsea hydraulic fluid in a closed loop system	Would eliminate the loss of hydraulic fluid from the subsea tree valves	Closed-loop systems would require an additional return line in the control umbilical, oil cleaning equipment in the HPU and additional equipment at each subsea tree, leading to increased complexity, cost and potential additional leak paths.	**Rejected** – Cost grossly disproportionate to environmental benefit. Other potential impacts arise

6.6.4 Environmental Impact Assessment

Receptor	Consequence Level
Planned Operations Discharges	
Threatened / migratory/ local fauna	Negligible – Changes to water quality may result in an alteration to marine fauna behaviour. Sea turtles, seabirds or marine mammals may come in contact with surface discharge for a short period should the transit through the area. However, the operational area is not known harbour significant numbers of these species and any visits of these fauna to the NV FPSO would likely be temporary only and prolonged negative impacts are not expected. The operational area overlaps pygmy blue whale BIA for distribution and marine fauna may transit through the operational area, however as explained above the discharge is unlikely to significantly impact the species and impact would be limited to behaviour only. The operational area overlaps the humpback whale BIA, the main migration path during the northward migration (July to October) of the humpback whale is centred along the 200 m bathymetric contour (Jenner et al., 2001), which is unlikely to intercept the operational area where the discharge occurs, impact to the migration of humpback whale is not anticipated. Chemical and terrestrial discharge is potential threats to a marine turtle species in Recovery Plan for Marine Turtles in Australia: 2017-2027 (**Table 3-8).** With control measures in place, the activity will be conducted in a manner that reduces potential impacts to ALARP and an acceptable level. The benthic habitat in the operational area is predominately unconsolidated sediments, comprising sand, silt and mud, with a very sparse assemblage infauna. Sub-lethal or lethal effects to infauna from chemicals / fluids discharged near the seabed, is considered unlikely given the expected low concentrations and short exposure times. Given the localised impacts in water quality from the discharge and the lack of any natural seabed features that would indicate a high abundance or

Receptor	Consequence Level
	diversity of demersal fishes within the operational area, it is expected that discharges would have a negligible impact on the demersal fish populations of the Continental Slope Demersal Fish Communities KEF. Given that planned operational discharges would not result in a decreased population size at a local or regional scale, it is expected that a discharge of this nature would result in a Negligible consequence.
Physical environment/ habitat	Negligible –The operational area overlaps the Continental Slope Demersal Fish Communities KEF (Section KEF), although habitat surveys of the Coniston/Novara fields revealed a flat soft sediment habitat comprising sand, silt and mud, and therefore fish abundance is expected to be low.
Socio-economic receptors	Negligible – Potential impacts to fishery resources (demersal fish species) are unlikely to result in changes in distribution and abundance of fish species outside the operational area No stakeholder concerns have been raised regarding this event.
Threatened ecological communities	Not applicable – No threatened ecological communities identified in the area over which planned discharges are expected.
Protected areas	Not applicable – No protected areas are identified in the area where planned discharges could affect water quality.
Overall worst-case consequence	I – Negligible

6.6.5 Demonstration of ALARP

Operational discharges will be required during the NV Operations for safe operations (e.g. cooling water discharges). Modelling of cooling water undertaken in 2010 showed that within 50 m from the FPSO a sea temperature increase of 2°C is predicted to occur less than 25% of the time. Additional modelling is not required due to the current cooling waters discharges from the FPSO not changing from the modelled parameters.

Alternative practices considered were to store some of the wastewater on-board (e.g. sewage, food waste, deck wash, bilge water), and periodically dispose of wastewater onshore, or to provide fresh water from shore. It is recognized that this will require more frequent vessel visits (and associated greater fuel consumption), may impact production operations (evaporator unit provides water for boilers) and require treatment of some of the waste streams at a licensed onshore facility. This would increase the environmental and safety risks associated with the NV Operations.

The use of water-based hydraulic fluid in an open-loop system is an improvement over using a closed-loop system, is in line with best industry practice, is internationally accepted and widely used in Australia. Closed-loop systems would require an additional return line in the control umbilical, oil cleaning equipment in the HPU and additional equipment at each subsea tree, leading to increased complexity, cost and potential additional leak paths. Furthermore, the current industry accepted closed loop systems use a mineral oil-based fluid and not a water-based fluid, which would increase environmental risks.

The use of AFFF for emergency purposes which also includes routine and contingency testing of that foam fire fighting system is critical for emergency response. Given the product has been assessed through the *Operations Chemical Selection Evaluation and Approval Procedure (EA-91-II-10001*), no additional controls were identified.

The use of chemicals to conduct testing on subsea infrastructure is a standard technique that is considered critical in determining the presence of leaks and infrastructure integrity. Alternatives to the use of methanol include freshwater. The use of freshwater in the subsea system can result in hydrate formation and introduce integrity risks, therefore it is not considered feasible. The use of treated seawater is also an industry standard and uses chemicals that have been appropriately risk assessed under the *Operations Chemical Selection Evaluation and Approval Procedure (EA-91-II-10001)*. The controls in place to manage the volume of treated seawater and chemicals used during subsea activities manages the volumes released to the ocean to ALARP.

The assessed residual consequence for this impact is negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.6.3)** but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact is ALARP.

6.6.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum planned operational discharge consequence is rated I (Negligible).
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes - Activity evaluated in accordance with the Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with + Marine Orders 91, 95 and 96 (vessels) + MARPOL Annex I, IV, and V (FPSO) + Recovery Plan for Marine Turtles in Australia: 2017-2027 Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this aspect.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Release of operations discharges into the sea from vessels in Australian waters is permissible under the relevant AMSA Marine Orders / MARPOL requirements. The operations discharges are not expected to significantly impact the receiving environment with control measures proposed, including compliance with relevant AMSA Marine Order / MARPOL requirements.

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMP values are expected. No stakeholder concerns have been raised regarding planned operational discharges from the NV Operations.

Given the nature and scale of effects to the environment, the impacts from planned operational discharges are ALARP and considered environmentally acceptable.

6.7 Discharge of Produced Water

6.7.1 Description of Event

Event	**Production Profile and Reservoir Behaviour Overview**

There is the potential for PW discharge overboard to the marine environment within the life of this EP (next five years). The inforce NV EP (Rev 7) provides for a variety of overboard PW discharges but historically PW discharge and impacts to the Commonwealth Marine Area have been avoided because of:

+ The high relative oil production from the original Van Gogh wells, the Coniston and Novara developments, and Van Gogh Infill wells. As the reservoir is depleted, the hydrocarbon contacts within the reservoir will continue reduce and the production profile from the reservoir through these wells will continue to become dominated by water production towards end of field life. The historical water production profile and an indicative water production forecast demonstrating this effect is shown in **Figure 6-1**.
+ The historically high reliability and uptime of NV's water processing and reinjection systems (wells, subsea flowlines, PW injection and processing equipment).

Whilst noting the 100% reinjection that has been achieved by the facility to date where historical demands on the PW processing system have been comfortably within the capacity, future demands are expected to be at (or exceed) nameplate capacity for sustained periods of time as detailed above. In anticipation of this change in production profile towards late field life, PW system upgrades were undertaken during the 2014-2015 shipyard campaign to reduce the OIW content of PW and mitigate against potential reliability issues typically experienced later in field life (refer to **Section 6.7.3**).

There are five key PW discharge scenario types outlined below. The scenarios below range from reinjection, to more likely small volume, short duration discharge events, through to a less likely late in field life permanent discharge scenario.

The produced water (PW) discharge scenarios considered in this Section are:

+ **Scenario 1:** Planned reinjection into the reservoir (**Table 6-17**);
+ **Scenario 2:** Temporary planned discharges to the marine environment for maintenance activity purposes (with the intention to return to reinjection post maintenance activity (**Table 6-18**);
+ **Scenario 3:** Temporary planned high oil in water discharge to the marine environment, limited to two specific events (with the intention to return to reinjection when upset condition resolved), preceded by a loss in PW injection capacity (**Table 6-19**);
+ **Scenario 4:** Temporary unplanned discharge to marine environment (with the intention to return to reinjection when failure condition resolved) (**Table 6-20**); and
+ **Scenario 5:** Permanent (partial to full) discharge to marine environment (**Table 6-21**).

Details on the events and criteria leading to overboard discharge scenarios to the marine environment are provided in **Table 6-18** to **Table 6-21.** Typical duration of discharge events and indicative number of events over the life of the EP are presented in **Table 6-18** to **Table 6-21** along with an indicative discharge volume over the life of the EP.

Figure 6-2 to **Figure 6-5** present the discharge decision pathway to be taken prior to discharge of Scenarios 2 to 5. The decision pathways aim to ensure that the PW system has appropriate controls in place prior to each of the discharge scenarios.

	Historic composition of PW is detailed in **Appendix G** together with toxicity testing results.
Extent	**Localised:** Under the reinjection scenario (Scenario 1), no PW is discharged to the marine environment. Under the temporary and permanent discharge scenarios (Scenarios 2-5), modelling indicates that the PW will form a plume, in surface waters only, stretching in the direction of the prevailing surface currents. Under a permanent discharge scenario modelling indicates that a plume may extend up to 459 m from the FPSO and that beyond this distance the 99% species protection limit will be achieved.
Duration	Temporary to permanent (partial to full) discharge

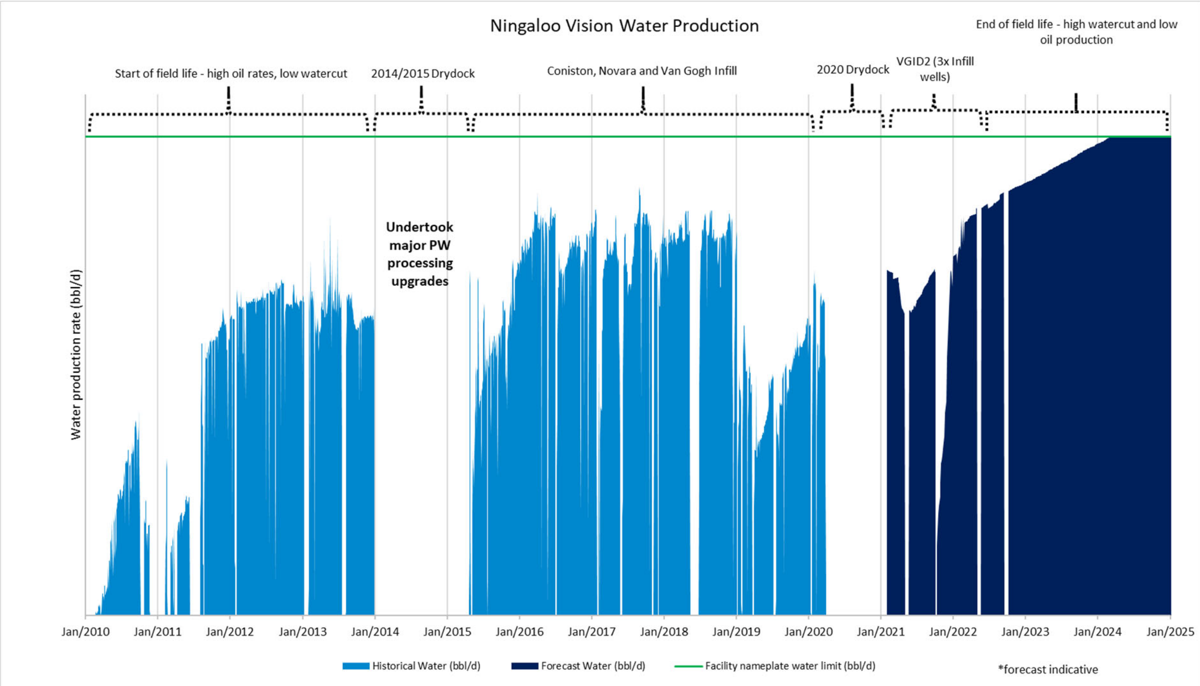

Figure 6-1: Ningaloo Vision Water Production

Table 6-17: Scenario 1: Planned PW Re-injection into the Reservoir Scenario

PW discharge scenario	Definition	Success criteria	Indicative duration of discharge per event (days)	Max. re-injection (per day)	Max OIW content (mg/l)	Max. overboard discharge per single event	Indicative number events over life of activity (5 yrs.)	Calculated overboard discharge over life of activity (5 yrs.)
Scenario 1: Reinjection	PW discharge to a subsea re-injection well	PW injection wells are available and able to be utilised, and the PW system is able to manage the PW volumes to the PW injection wells.	N/A	23,040 m^3	N/A	N/A	N/A	0

Table 6-18: Scenario 2: Temporary Planned Discharge to Marine Environment for Maintenance Activity

PW discharge scenario	Definition	Potential events leading to scenario	Discharge decision criteria	Indicative duration of discharge per event (days)	Max. discharge (per day)	Max OIW content (mg/l)[1]	Indicative number events over life of activity (5 yrs.)	Calculated overboard discharge over life of activity (5 yrs.) if event occurs [2]
Scenario 2: Temporary planned discharges to the marine environment for maintenance activity purposes (with the intention to return to reinjection post maintenance activity)	PW discharge to the marine environment during planned maintenance activity	Critical assurance activity (e.g. pump maintenance shutdown)	PW volumes exceed water pump capacity, above design capacity of 2 of the 3 PW injection pumps and PW volumes cannot effectively be managed by the slops tank Note: 3 PW pumps have a 23,040 m^3 per day capacity.	2 days	7,680 m^3 (assumes 1 pump shutdown only)	30	30	460,800 m^3
		Planned maintenance on power generation equipment or boilers requiring power load shedding (electrical load reduction) for operational requirements	One or more PW injection pumps need to be shut down in order to maintain stable electrical power across the facility and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	3 – 5 days	23,040 m^3	30	10	1.15 million m^3
		SIMOPS requiring planned PW system shutdown	PW system is inoperable and PW cannot be re-injected **and** PW volumes cannot be effectively managed by slops tank.	3 – 5 days	23,040 m^3	30	2	230,400 m^3

		Temporary increases in PW flow rates above those that can be re-injected by 3 pumps (e.g. high water cut wells online while reprocessing slops)	PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	1-2 days increasing to 6 months should high water cut occur.	23,040 m^3	30	26 events per / year = 130	6.45 million m^3 (Fortnightly)
							1 event (6 months)	4.2 million m^3 (6 months)

Note 1: Average OIW content over a rolling 24 hour period

Note 2: Typical overboard discharge over life of activity is based on: typical duration of discharge x maximum discharge per day x indicative number of events over life of activity

Table 6-19: Scenario 3: Temporary Planned High OIW Discharge to the Marine Environment

PW discharge scenario	Definition	Potential events leading to scenario	Discharge decision criteria	Indicative duration of discharge per event (days)	Max. discharge (per day)	Max OIW content (mg/l)[1]	Indicative number events over life of activity (5 yrs.)	Calculated overboard discharge over life of activity (5 yrs.) if event occurs [2]
Scenario 3: Temporary planned high oil in water discharge to the marine environment, limited to two specific events (with the intention to return to reinjection when upset condition resolved), preceded by a loss in PW injection capacity	PW discharge to the marine environment for period of up to 7 days	Any well coming on-line increasing OIW content due to slug flow and process instability	+ Water cut of total production volume exceeds the remaining PW system capacity + PW volumes cannot be managed effectively by slops tank + Preceded by a loss in PW injection capacity	Up to 7 days	23,040 m^3	70	2	322,560 m^3
		Start-up on return of FPSO from off-station (e.g. Short term dewatering of flowlines post cyclone disconnect/reconnect or shipyard return)	+ Water cut of total production volume exceeds the remaining PW system capacity + PW volumes cannot be managed effectively by slops tank + Preceded by a loss in PW injection capacity	3 – 5 days	23,040 m^3	70	2	230,400 m^3

Note 1: Average OIW content over a rolling 24 hour period

Note 2: Typical overboard discharge over life of activity is based on: typical duration of discharge x maximum discharge per day x indicative number of events over life of activity

Table 6-20: Scenario 4: Temporary Unplanned Discharge to Marine Environment

PW discharge scenario	Definition	Potential events leading to scenario	Indicative failure factors	Discharge decision criteria	Indicative failure frequency / Likelihood as per Risk Matrix (refer Table 5.3)	Indicative duration of discharge per event (days)	Max. discharge (per day)	Max OIW content (mg/l)[1]	Indicative number events over life of activity (5 yrs.)	Calculated overboard discharge over life of activity (5 yrs.) if event occurs [2]
Temporary unplanned discharge to marine environment (with the intention to return to reinjection when upset	PW discharge to the marine environment until the operational / failure issue is resolved	Loss of one or more PW injection or booster pumps within the PW system - Factoring in lead time replacement	+ Mechanical failure (e.g. seal failure on the pump) + Instrumentation or maintenance issue with the pump (s)	PW system is partially or fully inoperable and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	Between 1 and 10 incidents every 10 years	6 months	11,520 m^3	30	1	2.1 million m^3

condition resolved)		Power generation limitations requiring load shedding (electrical load reduction)	+ Breakdown of power generation equipment due to significant repair duration of boiler or HV power generators	Power generation load shedding requires one or more PW pump to be shut down, and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	Between 1 and 10 incidents every 10 years	1 year	23,040 m^3	30	1	8.4 million m^3
		Failure of topsides valving / pipework issues associated with the PW systems	+ Mechanical failure + Integrity issues on pipework	PW system is partially or fully inoperable and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	Between 1 and 10 incidents every 10 years	1 year	23,040 m^3	30	1	8.4 million m^3
		Topsides control system issue, associated with the PW injection system)	+ Control loop failure + Instrumentation (e.g. control valve failure) fault	PW system is partially or fully inoperable and water cut of total production volume exceeds remaining PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	Between 1 and 10 incidents every 10 years	6 months	23,040 m^3	30	1	4.2 million m^3
		Subsea control system issue so PW system is inoperable	+ Loss of communication to the subsea system	PW system is partially or fully inoperable and PW volume (from high production water cut) exceeds remaining PW system capacity to re-inject, and PW volumes cannot be managed effectively by the slops tank.	Between 1 and 10 incidents every 10 years	6 months	23,040 m^3	30	1	4.2 million m^3

Note 1: Average OIW content over a rolling 24 hour period
Note 2: Typical overboard discharge over life of activity is based on: typical duration of discharge x maximum discharge per day x indicative number of events over life of activity

Table 6-21: Scenario 5: Permanent (Partial to Full) Discharge to Marine Environment

PW Discharge scenario	Definition	Potential events leading to scenario	Indicative failure factors	Discharge decision criteria	Indicative failure frequency / Likelihood as per Risk Matrix (refer Table 5.3)	Indicative duration of discharge per event (days)	Max. discharge (per day)	Max OIW content (mg/l)[1]	Indicative number events over life of activity (5 yrs.)	Calculated overboard discharge over life of activity (5 yrs.) if event occurs [2]
Permanent discharge to marine environment	PW discharge to the marine environment for continuous period	Injection well injectivity decline due to sandface skin (clogging of reservoir injection zone), or unexpected increase in water cut.	+ Pressure differential (e.g. equalisation in pressure) between one injection well to another during a shutdown. + Reduction in injectivity due to clogging of injection well over time	PW volume is exceeding re-injection capacity of injection wells and OIW content is met.	Very unlikely	Ongoing from failure for remaining field life	23,040 m^3	30	1	42 million m^3
		Subsea flowline, valving integrity issue	+ Failure of PW injection flowline	Unable to reinject 100% of PW and OIW content is met	Very Unlikely	Ongoing from failure for remaining field life	23,040 m^3	30	1	
		Remaining gas cap volume uncertainty leads to the prioritisation of power generation for gas compression and gas reinjection	+ Gas cap depletion and low remaining volume estimates	Insufficient reservoir gas supply to supply fuel for remaining life of asset	Possible	Ongoing from failure for remaining field life	23,040 m^3	30	1	

Note 1: Average OIW content over a rolling 24 hour period
Note 2: Typical overboard discharge over life of activity is based on: typical duration of discharge x maximum discharge per day x indicative number of events over life of activity

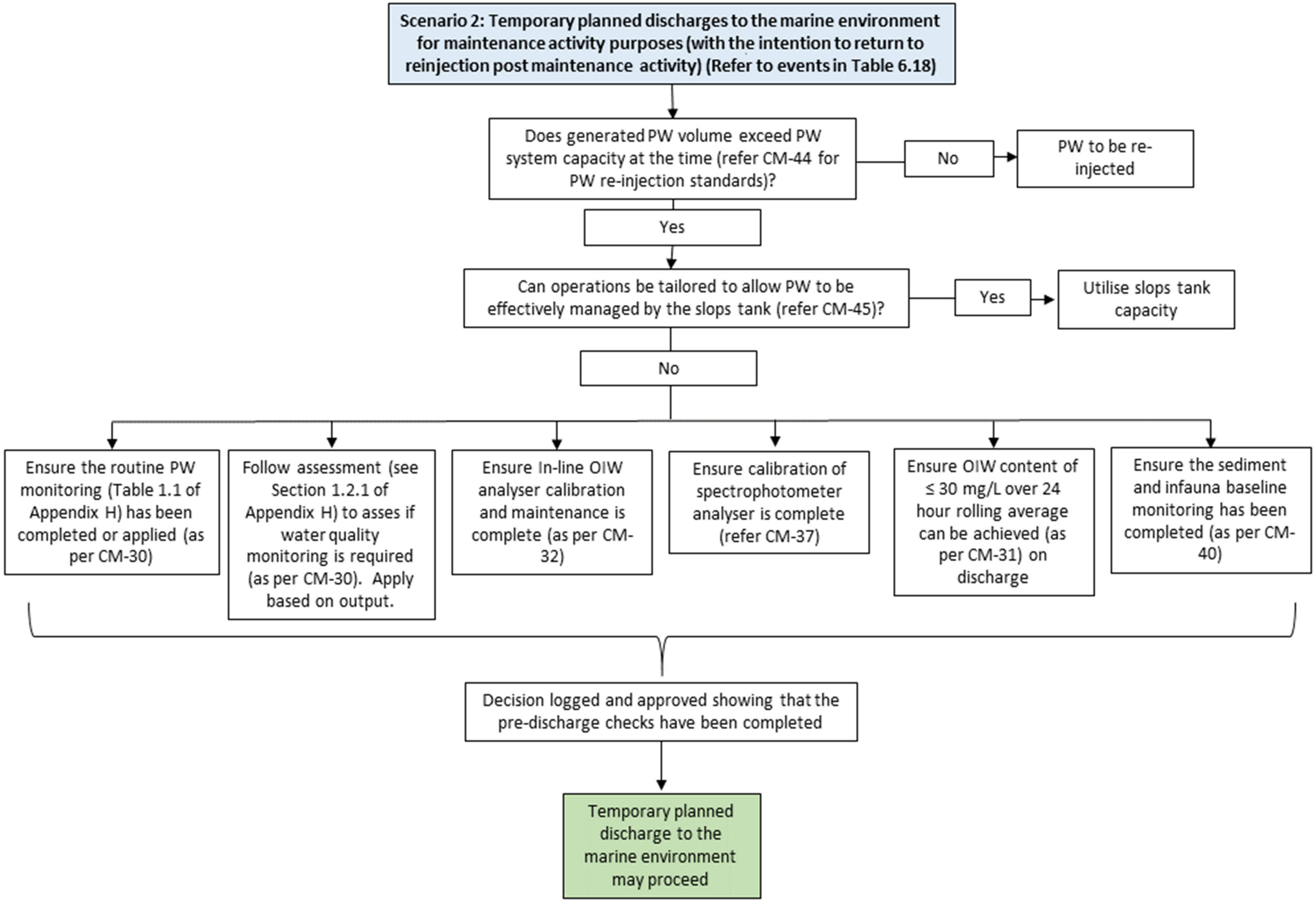

Figure 6-2: Scenario 2: Temporary Planned Discharge to Marine Environment for Maintenance Activity – Discharge Decision Pathway

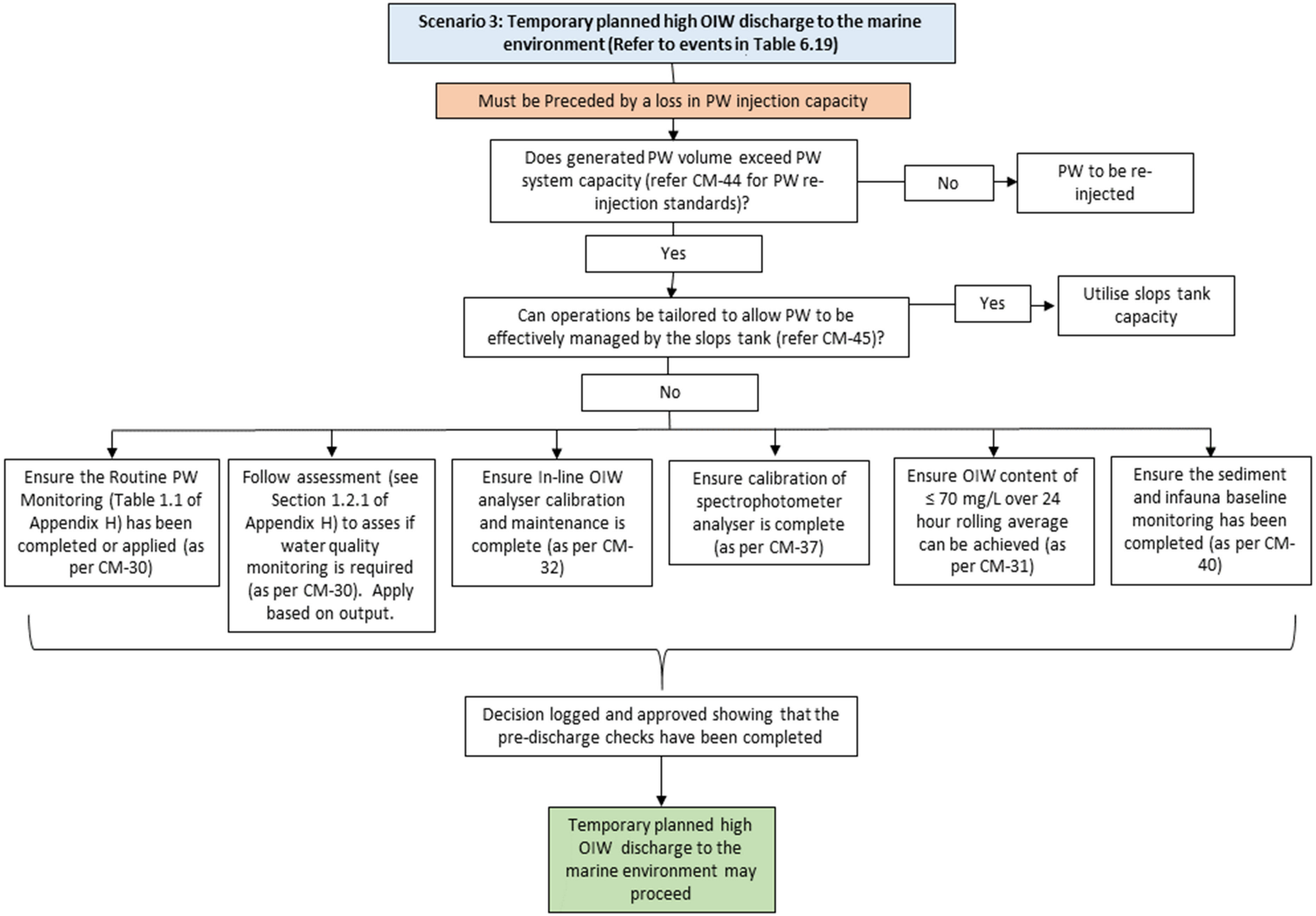

Figure 6-3: Scenario 3: Temporary Planned High OIW Discharge to the Marine Environment– Discharge Decision Pathway

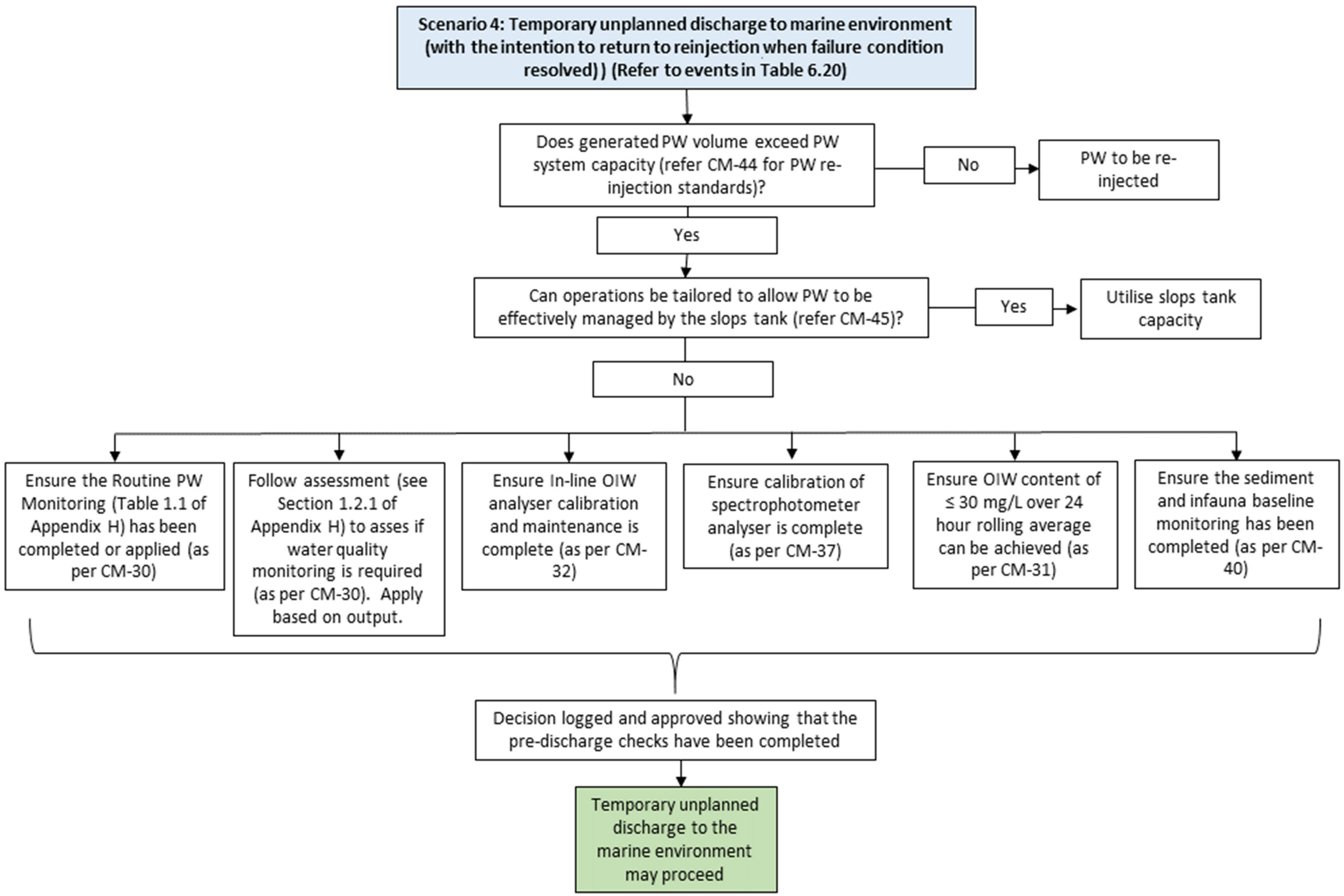

Figure 6-4: Scenario 4: Temporary Unplanned Discharge to Marine Environment– Discharge Decision Pathway

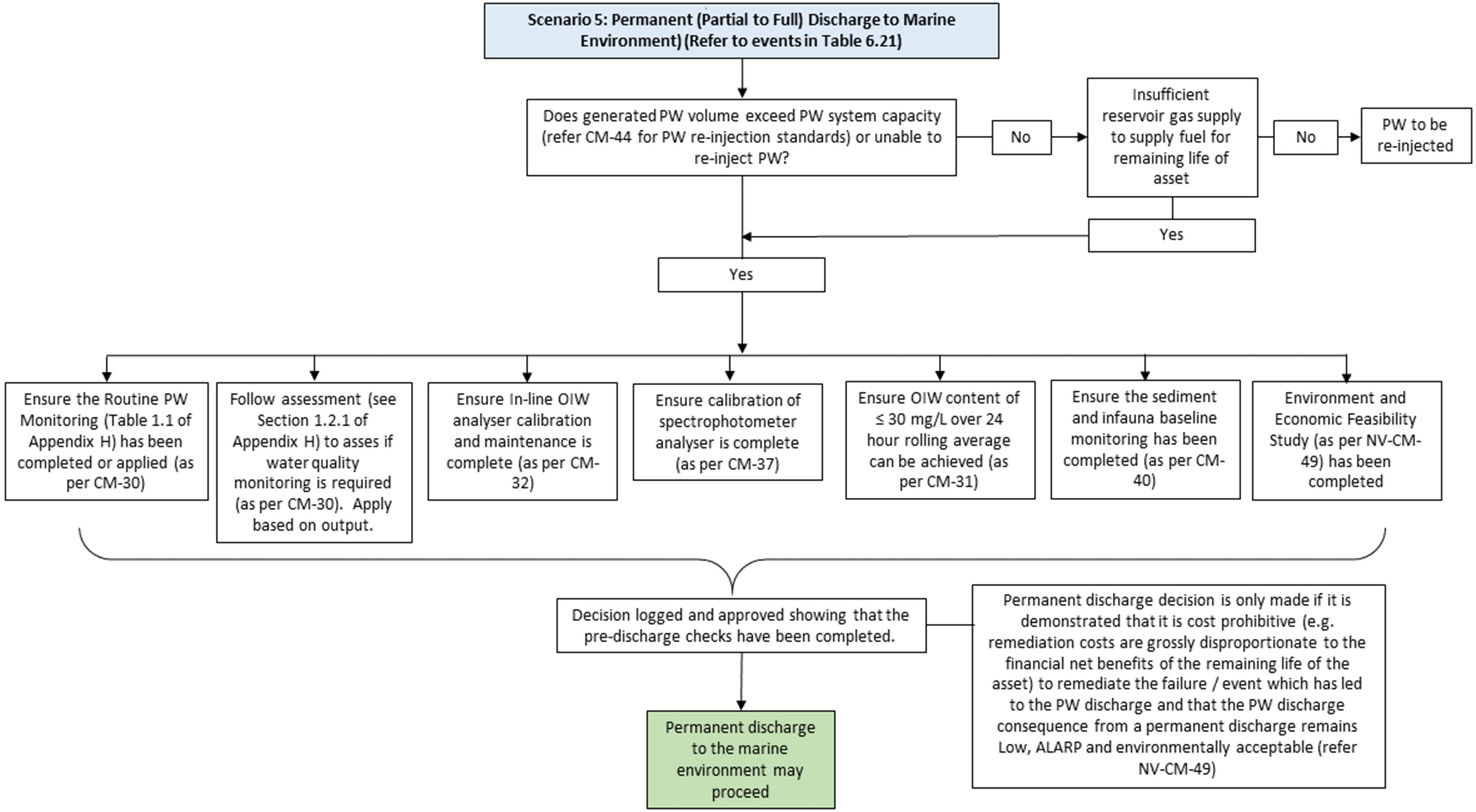

Figure 6-5: Scenario 5: Permanent (Partial to Full) Discharge to Marine Environment – Discharge Decision Pathway

6.7.2 Nature and Scale of Environmental Impacts

<u>Potential Receptors: benthic habitats, water column quality, marine fauna, protected/significant areas, socio-economic environment</u>

PW is brought to the surface from the reservoir during production. Water is separated out from the hydrocarbon components during the production process before being discharged to the marine environment. This water consists of formation water (derived from the aquifer below the hydrocarbon formation), condensed water (water vapour present within gas/condensate which condenses when brought to the surface), or a combination of both.

A summary of the potential impact mechanisms to receptors from the discharge of PW to the marine environment[5] and a detailed assessment of the potential impacts of PW discharge are presented below and include:

+ Change in water quality;
+ Bioaccumulation in marine fauna;
+ Toxicants in sediments; and
+ Eutrophication.

Modelling was undertaken by RPS APASA in January 2020 (APASA, 2020a) to provide an indication of the water column exposure extents from PW discharge. Results are discussed in **Section 6.7.2.5**.

6.7.2.1 Change in water quality

Potential impacts to water quality are to be assessed through chemical characterisation of PW and ongoing composition monitoring. Following the protocol outlined in ANZECC/ARMCANZ (2000) and ANZG (2018), a suite of bioassays was used to assess the toxicity of one produced water sample (Intertek 2019b, Intertek 2019c). Toxicity of NV PW is discussed in **Appendix G.**

PW often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (aliphatic and aromatic hydrocarbons, organic acids and phenols), and inorganic compounds (e.g. soluble inorganic chemicals, dissolved metals, etc.). PW may also contain traces of added process chemicals such as biocides, corrosion inhibitors, scale inhibitors, emulsion breakers, coagulants/flocculants and oxygen scavengers to the surface, which are required for the production operations (Johnsen et al., 2004, Neff, 2002). All these aforementioned chemicals may be used during NV operations and these are selected in accordance with the *Operations Chemical Selection, Evaluation and Approval Procedure* (EA-91-II-10001) (**Section 2.8.9.3**). Historic chemical quantities within NV PW are presented in **Appendix G**

BTEX are rarely included when considering the effects of PW since they evaporate rapidly from seawater (Neff et al., 2002, Neff et al., 2011, Terrens and Tate, 1996). However, for organisms in close contact with discharge points subtle biological effects may occur, caused by chronic exposure to BTEX over a longer period. More concern has been expressed due to discharges of 2–6 ring PAHs (discussed in the below section).

Metals in PW often include heavy metals such as arsenic, cadmium, copper, chromium, lead, mercury, nickel and zinc. Concentrations of dissolved trace metals within the NV PW are presented in **Appendix G** to allow for comparison of values against the ANZECC species protection values. The following exceedances are noted:

+ Dissolved copper exceeded ANZECC 95% and 99% species protection values in 2018

[5] Note: There are no potential receptors to the reinjection scenario.

+ Dissolved zinc exceeded 99% species protection values in 2018 and 2019, but values were below 95% species protection.
+ Chromium exceeded the 95% and 99% species protection values in 2016 and December 2019.

Azetsu-Scott et al. (2007) indicated three different pathways for these inorganic elements once entering the marine environment with PW:

1) elements that stayed in solution would dilute along with the PW plume;

2) elements that oxidize/precipitate to form insoluble inorganic compounds that would sink; and

3) elements that associate with oil droplets that are lighter than seawater and rise to the surface.

In a review of the environmental impacts of PW, Bakke. et al (2013) found no indication that levels of trace metals in fish and shellfish collected close to offshore installations are significantly above natural background concentrations.

The chemical composition of PW has been described in many scientific papers (e.g. Durell et al., 2006, Johnsen et al., 2004, Lee et al., 2005, Neff et al., 2011, Utvik, 1999, Utvik et al., 1999). These studies show high variability in PW composition from different fields. Utvik et al. (1999) found there was no correlation between the total hydrocarbon content (THC, present regulatory standard), and the content of aromatic compounds in PW. The toxicity of PW may be influenced by chemical partitioning and kinetics following discharge (Lee et al., 2005). Impacts should therefore be based on field-specific and detailed chemical characterization of each PW effluent (Bakke et al,. 2013).

Discharge of PW into marine waters introduces the above mentioned contaminants to the surrounding waters and results in a change in the local water quality that can increase the potential for toxicity for a period before the PW constituents disperse and dilute. During a permanent discharge to the marine environment, the change in water quality occurs over an extended period but is largely affected by the metocean conditions at the point of discharge, where currents, wind and wave action disperse and dilute the plume both across the surface of the ocean as well as through the water column. Based on modelling of the permanent discharge, the 99% species protection level (PC99) zone is achieved at a 459 m radius from the FPSO (the PW mixing zone, as defined in **Section 6.7.2.6**). The toxicity of the PW is presented in **Appendix G.** Increasing the total loads of contaminants discharged in the receiving water has the potential to increase bioaccumulation of toxicants within pelagic fish, phytoplankton, crustaceans or other marine species in the vicinity of the discharge, as discussed below.

6.7.2.2 Bioaccumulation in marine fauna

Bioaccumulation refers to the amount of a substance taken up by an organism through all routes of exposure (water, diet, inhalation, epidermal). Acute exposure to contaminants will result in serious harm or mortality to the marine organism whilst chronic exposure can lead to bioaccumulation of the contaminant within marine organisms over time (accumulation of chemicals from the water or from food sources into tissues over time). ANZECC/ARMCANZ (2000) and ANZG (2018) guidelines provide an indication of contaminants for which possible bioaccumulation and secondary poisoning effects should be considered. These include PAHs and the heavy metals mercury, selenium and cadmium.

Dispersed oil, PAH and alkylphenols, heavy metals, and naturally occurring radioactive material (NORM) are of particular environmental concern (Neff et al., 2011). PAH are defined as hydrocarbons containing two or more fused aromatic rings. These are the petroleum hydrocarbons of environmental concern in produced water because of their toxicity and persistence in the marine environment (Neff, 1987, 2002). Some PAH are known to be potent carcinogens and this class of contaminants is therefore given high priority for environmental pollution regulation and in risk assessment of industrial discharges (Bakke et al., 2013). Ecotoxicological issues related to PAH have been investigated in detail for many years and have been reported in a high number of scientific papers and reviews and include:

+ DNA damage (Aas et al., 2000);

+ oxidative stress (Sturve et al., 2006);
+ cardiac function defects (Incardona et al., 2004); and
+ embryotoxicity (Carls et al., 2008).

Uptake of PAHs can occur in all marine organisms to varying levels; however, level of up-take will vary dependent on conditions such as concentration and time of exposure, and species ability to metabolise these compounds (Meador *et al.*, 1995). Since elimination of PAHs is generally very efficient in fish and other vertebrates, bioaccumulation of PAH within these taxa do not generally reflect their level of exposure (van der Oost *et al.*, 2003).

Research has not documented effects of PW discharges on the population and community levels (Bakke et al,. 2013). Most of the laboratory and field studies of PW support a conclusion that significant biological effects on pelagic organisms will be limited to a distance of less than one km due to rapid effluent dilution and very short exposure time (Bakke et al,. 2013).

Uptake of dissolved hydrocarbons is less likely for marine mammals and reptiles than for fish and invertebrates, since marine mammals and reptiles are air breathing and do not possess gill structures that promote cellular uptake of dissolved constituents. Bioaccumulation of PAH has been mainly recorded within invertebrates which are less efficient at metabolising PAH. Bakke et al (2013) found that produced water accumulate in cod and blue mussel caged near outlets, but are rapidly metabolized in cod.

Concentrations of these contaminants in water column have been modelled RPS APASA (2020) and the potential for bioaccumulation has been assessed as per ANZG (2018) guidelines. Results are discussed in **Section 6.7.2.5**.

6.7.2.3 Toxicants in sediments

While the PW plumes are expected to occur mainly within surface waters, there is the potential for particles within the plume, which may comprise metal oxides and low solubility hydrocarbon droplets (such as higher molecular weight PAHs), to drop out of the plume in the far-field mixing zone (Neff et al., 2011). These components of the PW therefore have the potential to accumulate in sediments.

Accumulation of PW contaminants in sediments depends primarily on the volume and concentration of the contaminants in the PW and the amount of suspended solids and particle size to which they adhere. The suspended matter will eventually settle onto the seabed but the depositional area of the particulates will be largely determined by current speed and direction. Once on the seabed, the particulates will be subject to a range of physico-chemical processes such as re-suspension, bioturbation and microbial decay on the seabed.

Metals in PW include arsenic, cadmium, copper, chromium, lead, mercury, nickel and zinc. In the 2012 monitoring reports for all PW discharges on the NCS (Bakke et al,. 2013), results found elevated levels of these trace metals in sediments collected close to offshore installations, however, these elevated levels were attributed due to the disposal of drill cuttings (Bakke et al,. 2013) and not the discharge of PW. Despite the trace metal elevations in sediments, there was no indication that levels of trace metals in fish and shellfish collected close to the offshore installations were significantly higher than natural background concentrations (Bakke et al,. 2013).

Over the course of an extended duration of PW discharge (years) there is the potential for PAH and metals to accumulate within sediments surrounding the FPSO, the degree of which will be assessed through sediment sampling and monitoring as discussed in **Appendix H**.

Sediment deposition has been modelled by RPS APASA (APASA, 2020). Results are discussed in **Section 6.7.2.5**.

6.7.2.4 Eutrophication

Discharging nutrients (nitrogen and phosphorus) into the marine environment has the potential to increase the biomass of phytoplankton and bacteria within surrounding waters of the discharge location. This has the potential to occur during the PW discharge and up to hours/days after the discharge ceases.

6.7.2.5 Produced water predicted fate modelling

Produced water fate modelling was carried out by RPS APASA in 2020 (APASA, 2020) using the MUDMAP model, a three-dimensional plume behaviour model which simulates the PW mixing and dispersion.

Two discharge cases were modelled:

+ Modelling Case 1: A 30.5 mg/l scenario, which is indicative of the permanent discharge scenario (Scenario 5) and encompasses all other ≤30 mg/l scenarios (e.g. Scenarios 1, 2 and 4)
+ Modelling Case 2: A 74.5 mg/, which is indicative of the high OIW scenario (Scenario 3).

The MUDMAP model simulated the discharge into a time-varying current field with the initial dilution and shape of the discharge set by the near-field mixing results.

The PW model parameters used in the model are summarised in **Table 6-22**.

Table 6-22: Summary of PW Discharge Modelling Parameters

Parameter	Modelling Case 1	Modelling Case 2 (High OIW)
Location	NV FPSO	NV FPSO
Water Depth	340 m	340 m
Modelling Approach	Hindcast modelling period	Hindcast modelling period
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual
Maximum Volume	23,040 m^3/day	23,040 m^3/day
Maximum Flow Rate	960 m^3/hour	960 m^3/hour
Discharge Depth (m)	2-7 (above MSL) – depends on ship ballast at the time	2-7 (above MSL) – depends on ship ballast at the time
Initial concentration of sediment *	54.7 mg/L	54.7 mg/L
Number of simulations	300 (100 per season)	300 (100 per season)
OIW concentration	30.5 mg/L	74.5 mg/L
Average concentration of Suspended Solids	54.7 mg/L*	54.7 mg/L*

* For the purposes of estimating the sedimentation rate for suspended solids within the PW, an average concentration of suspended solids (54.7 mg/L) was applied following the average of the observed concentrations in four December 2019 PW samples (Intertek, 2019a).

The model outputs over the ten-year hindcast period (2009-2018) were combined and analysed on a seasonal basis (summer, transitional and winter). This approach assists with identifying the potential exposure to the surrounding area whilst considering inter-annual variability in ocean current conditions.

With respect to chemical contaminants, water quality in Australia is managed in accordance with the ANZECC/ARMCANZ (2000) and ANZG (2018) guidelines. The guidelines provide four levels of environmental protection that should theoretically protect 99, 95, 90 and 80 percent of marine species. These levels of protection are referred to as PC99, PC95, PC90 and PC80, respectively. To be able to define dilution factors to meet particular protection levels the toxicity of the PW was analysed by Intertek in 2019 (Intertek, 2019b), results are presented in **Appendix G**.

The results of the ecotoxicity assessment indicate the dilution factors by which the soluble components in the PW need to be diluted to in order to achieve each respective protection level associated with the effects on sensitive species (**Table 6-23**). Ecotoxicity assessment results (Intertek, 2019b), indicated that the dilution of the soluble components of the PW that must be achieved in order to protect 95% of species (based on their sensitivity) would be 128:1. For PC99 (99% species protection), a dilution of the order of 1,000:1 was calculated.

Table 6-23: Safe Dilution Factors for Produced Water

Species Protection Level	Modelling Case 1 (% sample)	Modelling Case 2 (% sample)
PC80*	4.5%	2.4%
Safe Dilution Factor	22	42
PC90	1.9%	0.79%
Safe Dilution Factor	53	1270
PC95*	0.78%	0.26%
Safe Dilution Factor	128	385
PC99*	0.1%	002
Safe Dilution Factor	1000	5000

* PC refers to protection level. The number designates the % of species afforded protection if concentration does not exceed the value

<u>Results – aqueous component</u>

Table 6-24 provides a summary of the maximum distance required to achieve safe dilution for each species protection level and season.

For each of the modelled discharge cases, the results for all simulations were combined and a statistical analysis performed to produce percentile contours of dilution. The contours of dilution do not represent the location of a plume at any point in time, however are a statistical representation and spatial summary of the percentage of time that dilution values occur across all replicate simulations and time steps The outcome is presented for average dilution contours, which is the statistic representing the central tendency of the contour. The use of the average statistic is considered to best represent the PW mixing zone under normal operating conditions and is also representative of background environment conditions.

The results indicate that the release of PW at 30.5 mg/l (Modelling Case 1) under all seasonal conditions should result in rapid dispersion within the ambient environment. Dilution to reach threshold concentrations at the species protection level PC99 (refer **Table 6-23**) would be achieved within 459 m of the FPSO for all seasons, (**Table 6-24**). which corresponds to a maximum exposure area of 0.1056 km^2 (**Table 6-24**). For a release of PW at 74.5 mg/l (High OIW) dilution to reach threshold concentrations at the species protection level PC99 (refer **Table 6-23**) would be achieved within 2,182 m for all seasons **(Table 6-25)**. This corresponds to scenario 3 which represents a maximum discharge duration of 7 days.

Table 6-24: Modelled maximum distance and total area of coverage from the PW discharge location to achieve OIW safe dilution factors in each season from the 30.5 mg/l sample (Modelling Case 1) (Discharge at 23,040 m^3 per day flow rate).

Species Protection Level	Safe Dilution Factor required to meet Species Protection Level	Statistic	Season	Maximum distance (m) from discharge location to achieve given dilution factor	Total area (km^2) of coverage for given dilution
PC80	22	Average	Summer	-*	-*
			Transitional	-*	-*
			Winter	-*	-*
PC90	53	Average	Summer	31	0.0004
			Transitional	31	0.0004
			Winter	31	0.0004
PC95	128	Average	Summer	31	0.0004
			Transitional	31	0.0004
			Winter	31	0.0012
PC99	1,000	Average	Summer	312	0.0540
			Transitional	328	0.0661
			Winter	459	0.1056

*achieved on discharge

Table 6-25: Modelled maximum distance and total area of coverage from the PW discharge location to achieve OIW safe dilution factors in each season from the 74.5 mg/l sample (Modelling Case 2 / High OIW) (Discharge at 23,040 m^3 per day flow rate).

Species Protection Level	Safe Dilution Factor required to meet Species Protection Level	Statistic	Season	Maximum distance (m) from discharge location to achieve given dilution factor	Total area (km^2) of coverage for given dilution
PC80	42	Average	Summer	31	0.0004
			Transitional	-	-*
			Winter	-	-*
PC90	127	Average	Summer	31	0.0004
			Transitional	31	0.0004
			Winter	31	0.0012
PC95	385	Average	Summer	77	0.0073

Species Protection Level	Safe Dilution Factor required to meet Species Protection Level	Statistic	Season	Maximum distance (m) from discharge location to achieve given dilution factor	Total area (km^2) of coverage for given dilution
PC80	42	Average	Summer	31	0.0004
			Transitional	-	-*
			Winter	-	-*
PC90	127	Average	Summer	31	0.0004
			Transitional	31	0.0004
			Winter	31	0.0012
			Transitional	97	0.0085
			Winter	142	0.0149
PC99	5,000	Average	Summer	1730	1.31263
			Transitional	1787	1.4608
			Winter	2182	2.2517

*achieved on discharge

Results – sediment component

For the purposes of estimating the sedimentation rate from suspended solids within the PW, an average concentration of suspended solids (54.7 mg/l) was derived from four samples of PW taken in December 2019 (**Table 6-26**). Critical to sedimentation rate calculations are specification of the sinking rates of solids, which are a function of the density, size and shape of the particulates (**Table 6-27**). Lighter and flake-shaped particles will settle slower than denser, rounded particles. Particulates in the PW are unlikely to have a uniform size, shape and density. PW from NV was analysed for particle size distribution as an input into the model and results are presented in **Table 6-26**.

Table 6-26: Total Suspended Solids within PW Samples Taken in December 2019 (Intertek, 2019b).

Sample	Total Suspended Solids (mg/l)
1	54.8
2	48.2
3	50.3
4	65.3

Results showed only a proportion of the larger particulate classes would likely contribute to seabed sedimentation within kilometres of the discharge (**Table 6-27**) (the model domain). The greatest contribution was by the medium and coarse silt (6.3-63 µm accounting for ~85.7% of the discharged mass) components that were specified to settle within 1-11.5 days, with some contribution by the fine silt (2-6.3 um accounting for 7.6%) and fine sand (63-250 um accounting for 6.7%) components. The finer sediments (<20 µm) were not predicted to settle within the model domain and would be expected to have a very wide dispersal at very low concentrations due to slow sinking rates and their longer-term transport by the prevailing currents.

Table 6-27: Measured size distributions, associated settling velocities and percentage particle size classes.

Grain Size Classification	Particle Size (µm)	Settling Velocity (cm/s)	Time to sink 348 m	% Particle Size
Fine Clay	<0.06	3.2×10^{-7}	3,496 years	0
Medium Clay	0.06-0.63	3.4×10^{-5}	31.7 years	0
Coarse Clay	0.63-2	3.5×10^{-4}	3.1 years	0
Fine Silt	2-6.3	3.4×10^{-3}	16.5 weeks	7.55
Medium Silt	6.3-20	0.04	1.6 weeks	42.54
Coarse Silt	20-63	0.34	1.2 days	43.18
Fine Sand	63-250	3.67	2.6 hours	6.73
Medium Sand	250-500	7.38	1.3 hours	0
Coarse Sand	500-2000	17.62	33 minutes	0

The modelled daily deposition rates were in the order of 0.1 g/m^2 or an annualised rate of 41 g/m^2 as shown in **Table 6-28.** In comparison, dry weight fluxes from sediment traps deployed in the North West Shelf ranged from 0.124 to 0.616 g m^2 day (Burns et al. 2003) indicating that sedimentation rates from suspended solids are less than background. It should also be noted that these annual rate calculations likely overestimate rates of deposition on the seabed of the coarse silt component, because it does not account for the shear-stress that would be generated by currents flowing along the seabed that may inhibit settlement. Moreover, calculations account for input estimates only, with no calculation for sediment resuspension. The rate and net deposition of sediment does not relate to any physical threshold that could impact seabed fauna and any oil that is attached to the particles is subject to rapid degradation at the sediment interface (Burns et al. 2003) such that no accumulation is likely.

Table 6-28: Maximum daily and yearly sedimentation deposition rates in each season at any one location (Discharge at 23,040 m^3 per day flow rate)

Statistic	Season	Deposition Rates	
		Daily (g/m^2)	Annual (g/m^2)
Average	Summer	0.114	41 (approximately)
	Transitional	0.109	
	Winter	0.113	

6.7.2.6 Defining the PW mixing zone

The PW mixing zone boundary is defined as a radius of 459 m around the FPSO (**Figure 6-6**) for a discharge at ≤30 mg/l (indicative of PW Scenarios 1, 2, 4 and 5). At this distance, dilution is sufficient to achieve threshold concentrations for the PC99 species protection level.

As detailed in above, the PW mixing zone is extended to a radius of 2,182 m around the FPSO during a release of PW at 74.5 mg/l (Modelling Case 2 / High OIW), which is indicative of PW Scenario 4 (≤70 mg/l discharge). The modelling results are conservative and the PW mixing zone would only be extended to this distance for a maximum of 7 days (refer to **Table 6-19**).

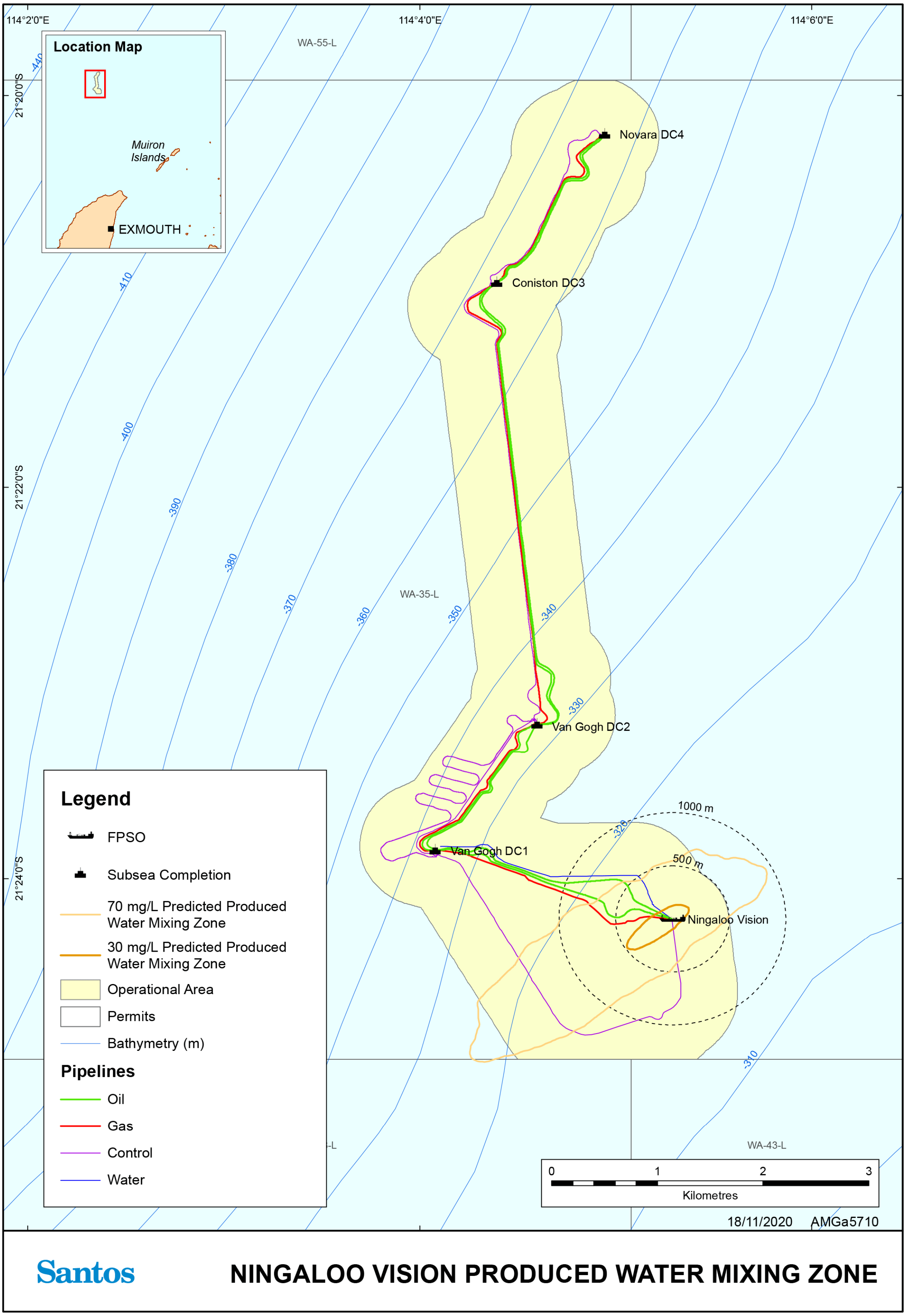

Figure 6-6: Ningaloo Vision Produced Water Mixing Zone

6.7.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ Limit adverse impacts to the values and ecological integrity of the Commonwealth marine area by ensuring a species protection level of PC99 (based on ANZG 2018) for water quality is achieved outside the PW mixing zone boundary* [EPO-NV-06].

  *PW mixing zone determined to be 459 m from the FPSO during a <30 mg/l PW discharge and 2,182 m from the FPSO during a <70 mg/l PW discharge

+ Limit adverse impacts to values and ecological integrity of the Commonwealth marine area by ensuring ANZG 2018 sediment quality guideline values are not exceeded outside the 30 mg/l PW mixing zone [EPO-NV-07].

The control measures considered for this activity are shown below (**Table 6-29**). EPS and measurement criteria for the adopted controls are presented in **Table 8-2**.

Table 6-29: Control Measures Evaluation for Produced Water

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls					
NV-CM-30	Scenario 2 Scenario 3 Scenario 4 Scenario 5	PW Adaptive Management Plan (**Appendix H**)	Implementation of PW Adaptive Management Plan reduces potential impacts of PW discharge to the marine environment and ensures criteria are met prior to and during temporary and permanent discharge to the marine environment.	Costs associated with implementation of PW Adaptive Management Plan and its implementation.	**Adopted** – Benefit of reducing potential impacts by meeting acceptable PW quality criteria and through ensuring a 'state of readiness' prior to discharge outweighs the associated costs.
NV-CM-29	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Chemical Selection Procedure	Chemicals are risk assessed and only environmentally acceptable chemicals are used on the FPSO and discharged with the PW.	Cost associated with implementation of procedure. Range of chemicals reduced with potentially higher costs for alternative products.	**Adopted** – Benefit of using environmentally acceptable chemicals outweigh procedural implementation and operational costs.
NV-CM-31	Scenario 2 Scenario 3 Scenario 4 Scenario 5	OIW content for PW discharge to the marine environment is limited to ≤ 30 mg/L (rolling 24 hour average)	Limiting the OIW content of PW discharge reduces the potential environmental impact of PW discharge on the marine environment to within the PW mixing zone.	Cost associated with production limitations, and changes in order to achieve ≤30 mg/L (rolling 24-hour average)	**Adopted** – Benefit of limiting OIW content of PW discharged outweighs the associated costs.
		Temporary high OIW discharge scenarios (**Table 6-19**) which is limited ≤70 mg/L over a rolling 24 hour average, for a period of time no greater than 7 days	Limiting the scenario to certain criteria and a duration of no greater than 7 days.	Cost associated with the inability to restart, and needed to drive production back to ≤30 mg/L (rolling 24 hour average)	**Adopted** – Benefit of temporary high OIW provides ability to re-establish production and drive to less than 30 mg/L to enable ongoing production.
NV-CM-32	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Inline OIW analyser to continuously monitor the OIW concentrations	Monitoring OIW content confirms OIW content is within discharge limits of ≤ 30 mg/L (rolling 24-hour average). The OIW analyser is able to alert the operator at both ≤30 mg/l and >25 mg/l so discharge can cease to the marine environment as required.	Cost associated with calibration and maintenance of inline OIW meter. Costs associated with operating of the OIW analyser	**Adopted –** Benefit of monitoring OIW content of PW discharged outweighs the associated costs.
NV-CM-33	Scenario 2 Scenario 3 Scenario 4 Scenario 5	In-line OIW analyser calibration and maintenance	Calibration of the OIW in line analyser ensures OIW reading are reliable and prevents discharges of OIW above the discharge limit to the marine environment.	Costs associated with calibration of the OIW meter.	**Adopted–** Benefit of preventing OIW discharges above discharge limit outweighs the associated costs.
NV-CM-34	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Manual laboratory spectrophotometer sampling of PW OIW content concentrations	Manual laboratory sampling of PW using the spectrophotometer provides assurance that the PW discharged to the marine environment is reliably measured by the OIW analyser and discharged at ≤30 mg/l (rolling 24-hour average).	Cost associated with taking and analysing samples.	**Adopted –** Benefit of monitoring OIW content of PW discharged outweighs the associated costs.
NV-CM-35	Scenario 2 Scenario 3 Scenario 4 Scenario 5	NATA laboratory sampling for chemical characterisation	Chemical characterisation of PW provides an understanding of the composition of the PW. Understanding the chemical characterisation is important in ensuring impacts are not outside of the PW mixing zone	Cost associated with taking and analysing samples.	**Adopted** – Benefit of monitoring chemical characterisation of PW discharged outweighs the associated costs.

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-36	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Laboratory sampling for ecotoxicity	Ecotoxicity testing of PW provides assurance that the PW discharged to the marine environment is not posing a significant risk to the environment. Measuring the ecotoxicity is required to confirm the safe dilution factors and ensures the PW mixing zone applied is accurate.	Cost associated with taking and analysing samples.	**Adopted–** Benefit of monitoring chemical characterisation of PW discharged outweighs the associated costs.
NV-CM-37	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Onboard laboratory spectrophotometer calibration	Calibration of onboard laboratory spectrophotometer calibration ensures OIW reading are reliable and prevents discharges of OIW above the discharge limit to the marine environment.	Costs associated with calibration of the onboard laboratory spectrophotometer.	**Adopted–** Benefit of preventing OIW discharges above discharge limit outweighs the associated costs.
NV-CM-38	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Onboard laboratory chemical sampling	Ensuring laboratory chemical sampling is carried out in a manner which prevents contamination of OIW samples ensures that OIW results are reliable and prevents discharges of OIW above the discharge limit to the marine environment	Minor cost involved with implementing a process to ensure OIW samples are taken in a manner which avoids contamination.	**Adopted–** Benefit of preventing OIW discharges above discharge limit outweighs the associated costs.
NV-CM-39	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Water quality sampling and dye test (or equivalent)	Infield water quality sampling will provide verification that impacts at PC99 are not outside of the PW mixing zone and will verify PW modelling aqueous component. A dye test or equivalent is undertaken by discharging a dye through the PW system during a PW discharge, in a manner that represents a volume and rate based on the reservoir characteristics and water cut at the time of the testing. The dye indicates where the PW plume is, and is used to inform where water samples are taken, in order to validate the PW mixing zone boundary.	Cost associated with vessel use, sampling and analysis	**Adopted–** Benefit of monitoring water quality outweighs the associated costs.
NV-CM-40	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Sediment quality sampling	Infield sediment quality sampling will provide verification that impacts at PC99 are not outside of the PW mixing zone and will verify PW modelling sedimentation rates.	Cost associated with vessel use, sampling and analysis	**Adopted–** Benefit of monitoring water quality outweighs the associated costs.
NV-CM-04	Scenario 2 Scenario 3 Scenario 4 Scenario 5	FPSO Planned Maintenance System and class certification system	Ensures that PW equipment (including all equipment associated with the processing of PW) maintained and is operating within its parameters.	Costs associated with maintenance of equipment.	**Adopted -** Benefits of operating PW equipment within operational parameters will help meet PW concentration limit.
NV-CM-41	Scenario 4	Critical spare PW re-injection pump availability	Holding and purchasing a critical spare PW reinjection pump allows for expedited replacement of an existing PW re-injection pump in the event of failure. Holding a spare PW re-injection pump will allow quick replacement and limit the discharge to the marine environment which otherwise would be extended whilst a spare pump is sourced.	Reasonable costs involved with purchase and storage of the spare pump.	**Adopted –** Environmental benefits in quick replacement of the PW re-injection pump and limiting the PW discharge outweigh the costs involved with purchase, storage and maintenance of the spare pump.
NV-CM-42	Scenario 2	Plan to only shutdown one PW re-injection pump at a time during planned pump maintenance	Planning to only shutdown one PW re-injection pump and leaving the other two running will allow some re-injection of PW to occur during planned PW pump maintenance, therefore will limit the discharge to the marine environment	Negligible costs involved with planning maintenance schedule.	**Adopted –** Environmental benefits of planning to only shutdown one PW re-injection pump during planned pump maintenance limits PW discharge to the marine environment and costs

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
			which otherwise would be at an increased rate should greater than one pump be shut down.		involved outweigh the environmental benefits.
NV-CM-43	Scenario 2 Scenario 4	PW treatment system inspection testing and maintenance	The PW system is inspected, tested, and maintained in accordance with: + PS-03 Hydrocarbon Containment; Risers and Pipelines (NV-00-RG-10053.03) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). + PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08 This aims to ensure the integrity and functioning of water injection and topsides produced water treatment are fit for purpose and able to provide hydrocarbon containment / PW. Therefore, reduces likelihood of failures leading to unplanned temporary PW discharge events.	Negligible personnel costs associated with inspections, testing and maintenance.	**Adopted** – Environmental benefits outweigh the costs of personnel time
NV-CM-44	Scenario 2 Scenario 3 Scenario 4	PW re-injection	PW is re-injected (i.e. not discharged overboard) 100 percent, up to 23,040 m^3 per day, unless operating under events under Scenario 2, 3, 4 or 5, as described in Tables 6-18 to 6-21. The power generation, PW pump capacity and PW system injection capacity has a nameplate design capacity for reinjection of 23,040 m^3. Instances which can and have historically led to a reduction in the PW system injectivity are those planned PW discharge events detailed in Table 6-18. During these events the PW system capacity is reduced and PW is re-injected at the maximum re-injection rate, specific to the event. Surplus PW is discharged (or managed by slops if feasible). Re-injection of PW ensures the elimination of PW discharge to the marine environment.	Negligible cost as the PW re-injection is setup on the FPSO. Cost involved in maintaining ability to re-inject.	**Adopted –** Environmental benefits in reducing or negating a discharge to the marine environment when pump capacity and well injectivity outweigh the cost.
NV-CM-45	Scenario 2 Scenario 3 Scenario 4	Slops tank is managed and utilised for PW discharge when operationally feasible	Utilising the slops tank for disposal of PW will reduce or in some circumstances (e.g. very short period re-injection is unavailable) negate the requirement to discharge PW to the marine environment. The slops tank has a limited capacity and will only be able to receive PW for a matter of hours based on name plate PW discharge rate and can only receive until it is full. Discharge to environment may still be required.	Negligible cost as the PW system is designed to divert to slops tank and PW divert there when available / operationally feasible.	**Adopted –** Environmental benefits in reducing or negating a short period of discharge to the marine environment outweigh the cost
NV-CM-46	Scenario 2 Scenario 4	PW flowline is operated within design pressure limits	Operating the PW flowline within its design pressure limits will reduce the likelihood of PW system issues which could lead to a temporary unplanned loss of PW re-injection or requirement for planned maintenance and therefore the potential PW discharge to the marine environment	Reasonable cost involved in monitoring pressure in the flowline	**Adopted -** Environmental benefits in reducing likelihood of a discharge I of PW to the marine environment due to unplanned PW system failure outweigh the negligible cost.
NV-CM-47	Scenario 4 Scenario 5	Van Gogh Operating Procedure Subsea System Start-up (Depressurisation) (TV-35-IG-00195)	Start-up process of the subsea system is managed in accordance with Van Gogh Operating Procedure Subsea System Start-up (Depressurisation) (TV-35-IG-00195). The procedure includes the requirement that water injection	Negligible cost in following start-up procedure	**Adopted -** Environmental benefits in reducing likelihood of a discharge of PW to the marine environment due to

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
			should never be started up in both water injection wells at the same time. Opening both wells at the same time, prior to starting injection, can lead to water back-flow and cross-flow between the wells and sand fill. Dependent on the severity this can result in a complete loss of infectivity in one or both wells. Losing partial or full injectivity can lead to a temporary or permanent discharge of PW to the marine environment.		partial or full loss of injection well outweigh the negligible cost.
NV-CM-48	Scenario 4 Scenario 5	Use and management of corrosion and biocide treatment to maintain integrity of the PW system	Corrosion and biocide are used within the PW system to maintain integrity, therefore reducing the likelihood of unplanned PW system issues which lead to a temporary loss of re-injection and potential PW discharge.	Negligible cost involved with chemical purchasing and use	**Adopted** – Low environmental impacts in order to maintain system integrity.
NV-CM-49	Scenario 5	Environment and Economic Feasibility Study prior to permanent discharge decision	Utilising an Environment and Economic Feasibility Study prior to a permanent discharge decision ensures that if an event leading to a permanent discharge (refer to Table 6-21 for events), remediation is investigated as part of the study to ultimately limit or mitigate PW discharge to the marine environment. The permanent discharge decision is only made if it is demonstrated that + it is cost prohibitive (e.g. remediation costs are grossly disproportionate the financial net benefits of the remaining life of the asset) to remediate the event which has led to the PW discharge; and + that the PW discharge consequence from a permanent discharge remains, ALARP and environmental acceptable	Negligible cost involved in performing study	**Adopted** – Environmental benefits of performing the feasibility study prior to a permanent discharge decision outweighs the cost. If it is feasible to remediate failures these actions will be applied which negate a premature permanent discharge from occurring.
NV-CM-50	Scenario 5	PW continuous improvement during permanent discharge	An annual review of permanent PW discharge scenario for continuous improvement to demonstrate it remains ALARP and environmentally acceptable. The annual review ensures that Santos are actively assessing the availability of improvements in technology and engineering to improve PW discharge quality. This includes a review of: + Technology available to reduce oil in water content + Technology to reduce PW discharge volumes + The identification of any new relevant industry regulations or guidance. + A review of the environmental assessment and relevant existing approvals, any changes to environmental sensitivities (e.g. EPBC Act Listed Protected Matters), any newly identified literature studies and the environmental acceptability of permanent discharge Adopting relevant recommendations from the annual aims to keep permanent discharge of PW ALARP and environmentally acceptable.	Operational and personnel cost in performing the review	**Adopted** – Provides for an improved understanding of a potentially available technologies, that may result a reduction of environmental impact. Adopting the recommendations of the review aims to ensure that permanent discharge of PW ALARP and environmentally acceptable.
Additional Controls					

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
N/A	Scenario 2	Maintaining availability of more than one critical re-injection pump	Maintaining the availability of more than one critical re-injection pump gives further assurance that should two break there is a spare available.	Unreasonable cost in purchase and maintaining additional re-injection pump. Santos already maintain and store one re-injection pump.	**Reject –** There has not been a requirement for use of the existing critical PW re-injection pump in operations to date (> 10 years) and it is highly unlikely that multiple pumps will fail. The cost to purchase and maintain two critical spare pumps outweighs the potential minor reduction in environmental impact that may be achieved.
N/A	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Increase the size of the slops tanks	Increasing the slops tank capacity will allow for an additional PW volume to be discharged into it, in the event that the PW re-injection is unavailable.	There is not adequate space on FPSO to increase the slops tank capacity (refer to Ningaloo Vision Produced Water Treatment System Study -NV-22-RP-2002), significant redesign, and reconstruction of the entire FPSO would be required. The FPSO was designed and constructed with the current slops tank and is class certified to the current slops tank capacity. An increase in slops tank capacity may impact the FPSO class certification due to: + Additional weight on the FPSO + Impact to buoyancy of the FPSO	**Reject –** It is not feasible to increase the size of the slops tank, given it forms a significant part of the structural integrity of the hull. The slops tank is below deck and has been designed and built to accommodate slops. There is no available space currently to increase the size of the slops tank without major vessel redesign and reconstruction. Time (potentially 12-18 months in shipyard for this scope) and cost associated with required changes are prohibitive for the life of the asset.
N/A	Scenario 2 Scenario 3 Scenario 4	Use of cargo tank in addition to slops to mitigate short duration discharge	A crude cargo tank may be used in addition to the slops tank to contain PW in the event that the reinjection is unavailable, negating the requirement to discharge to the marine environment for an additional period (assumed 1-2 hours typically, based on name plate PW system flowrate and cargo capacity).	The option of holding PW in cargo tanks was considered and was not feasible as it would create integrity issues with the tanks, (which are not designed or constructed to be filled with PW) and require unsustainable increased offtake tanker frequencies, which present risks: + Risk of corrosion increases within the crude tank due to the PW presence. + Closer to the offtake dates there is limited capacity in the tanks therefore limited capacity to hold PW. + Should the cargo tank be full from PW, production will have to stop or decline until an offtake tanker arrives. + Use of the cargo tank to contain PW, risks contaminating the crude quality and may impact its sale price of the crude + Reduction of crude parcel volume (as a result of utilising crude tanks for PW storage) would threaten the ability to market the product efficiently.	**Reject –** Using the cargo tanks is not feasible as it would create integrity issues with the tanks, and require unsustainable increased offtake tanker frequencies due to there being less room for oil cargo stores, which present its own additional risks (e.g. vessel collisions). The cost outweighs the environmental benefit of negating a PW discharge to the marine environment for a short period of time.
N/A	Scenario 2 Scenario 3 Scenario 4	Maintain a formal contingency volume in the slops to avoid a discharge to the marine environment	A formal contingency volume could be kept within the slops tank to be used in the event that re-injection of PW is unavailable for a short period. However, a formal contingency volume would only be able to capture PW for a very short period (1-2 hour based on name-plate PW system flow rates) with little environmental benefit presented.	The slops tank use is constantly required during production and many waste streams enter the slops tanks. It is not practical or safe to maintain a contingency volume for the PW within the tanks on a formal basis.	**Reject –** This control is not feasible (not practical or safe to maintain a contingency volume within the slops tank).

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
N/A	Scenario 3	Cutting back production / flow to minimise high OIW PW (≤70 mg/l) events.	Reducing oil production / flow will reduce the high OIW PW volume discharged	Cutting back production and flow during start-up is not feasible. On start up the flowrates and temperatures in the flowlines and systems are highly variable in order to allow effective start-up of the FPSO and its production systems. Reducing the flow and temperatures will result in significant process issues.	**Rejected** – Cutting back production and flow during start-up is not operationally feasible due to the flowrates and temperatures in the flowlines being relied upon to provide effective start-up of the FPSO and its production systems. The cost of cutting back production for a week outweighs the minor environmental impact of a short duration (no more than 7 days) event.
N/A	Scenario 2 Scenario 3 Scenario 4	No discharge of PW to the marine environment during humpback whale and pygmy blue whale migration periods.	Would reduce the likelihood of humpback whale and pygmy blue whale PW exposure during transiting / migration, should they enter the PW mixing zone.	Disallowing a PW discharge in certain months is not feasible. The scenarios defined in Section 6.7.1. are a combination of planned and unplanned discharges, the exact timings of failure is not able to be determined. Furthermore, planned maintenance is required to happen at certain times and delay may result in unacceptable safety risks.	**Rejected** – The exact timings of failure leading to an unplanned event is not able to be determined. Furthermore, planned maintenance is required to happen at certain times and delay may result in unacceptable safety risks. The significant cost of lost production through not being able to discharge to the marine environment in certain migratory period months is grossly disproportionate to the reduction in environmental impact that may be achieved, given the minor nature of the impacts.
N/A	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Preventatively or reactively drill additional reinjection well/s or conduct well intervention on reinjection well	If a new well is drilled, it would allow PW to be re-injected into another well rather than be discharged to the marine environment. If an intervention is pre-emptively undertaken, it may prevent or delay the requirement for PW discharge to the marine environment as re-injectivity is maintained, allowing maximum PW reinjection at nameplate capacity (23,040 m^3 per day).	Water injection wells were designed and constructed as part of the field development plan for the life of the field. Historical use has not shown any leading indicators of failure over the operational life of the facility. In assessing the potential for Drilling additional re-injection wells or increasing re-injection system Santos has taken into account the scope of The Project assessed and approved by the Minister for the Environment. The scope of the original project allowed for a discharge of PW overboard for 10% of the time under normal operating conditions. Drilling of a new re-injection well costs approximately $50 – 100 million. Drilling of a new well will pose other environmental impacts / risks (cuttings discharge, oil spill risk). Permanent discharge to marine environment only occurs as a result of two failure events: + Injection well injectivity decline due to sandface skin, or unexpected increase in water cut + Subsea flowline or valving integrity issue Drilling of a new re-injection well pre-emptively would result in significant cost ($50-100 million) with little	**Rejected** – The high cost of drilling a new well or conducting well intervention on current wells prior to a failure is not economical or practical given the long lead time, and where the asset is operating late in life.

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				environmental benefit, particularly given the very unlikely likelihood of failure and uncertainty around failure timing (more likely later in field life), and only the partial loss of reinjectivity typically being associated with these types of failures, should it occur at all. Drilling of a new injection well after a failure occurrence is unlikely to be economically and practically feasible due to the long lead time for subsea equipment (XTs) procurement and time taken to drill and tie in a new well (e.g. 18 – 24 months from time of failure), in addition to the high cost of subsea equipment procurement. Pre-emptively conducting a well intervention in an attempt to assure continued water injection capacity is not considered reasonable, or practicable given the significant cost ($25-35 million per well) and no environmental benefit due to an absence of actual failure (or leading indicators that failure will occur). Furthermore, intervention may not be successful in increasing / maintaining injectivity or may only be successful for a short period. Permanent discharge to marine environment only occurs as a result of two potential failure events: + Injection well injectivity decline due to sandface skin + Subsea flowline or valving integrity issue Water injection well injectivity is monitored over, allowing for any downward trends in injectivity to be identified and investigated with the aim to restore injection capacity (e.g. through chemical treatments) where feasible, before further capacity to reinject is lost. Unwarranted intervention also presents other safety and environmental risks (e.g. associated with vessel use over subsea infrastructure) As discussed in Section 2.14, cessation of operation may also occur within the life of this EP. The re-injection well may only be utilised for a short period (if at all), relative to the overall life of the field. Therefore, presents a high cost with little certainty over environmental benefits.	
N/A	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Transport PW to shore via vessel	Discharge of PW to a vessel tank would result in zero PW discharge to the marine environment.	PW volumes per day are vastly in excess of vessel storage and would require many vessels operating on a 24 hour basis between the FPSO and shore. This presents additional risks (e.g. spill risk, vessel presence, discharge). The tanker offloading line would need to be used to pump PW to a vessel – risking corrosion of the line and further risks.	**Rejected** – The high cost of having multiple vessels on contract, additional environmental risks with off taking PW, plus the cost and potential environmental and safety issues associated with onshore transport/management and disposal outweighs the environmental impacts that could be avoided through not discharging to the marine environment.

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
N/A	Scenario 2 Scenario 3 Scenario 4	Increase existing PW reinjection system (replacement / upgrade of pump module) and subsea system capacity	Will increase the PW re-injection rate and allow more PW to be reinjected rather than be discharged marine environment.	The FPSO was built to a accommodate the current PW reinjection system and is class certified for the current system. An increase in PW reinjection system capacity may impact the FPSO class certification due to: + Additional weight on the FPSO + Impact to buoyancy of the FPSO + Power generation is designed for the existing pumps and nameplate capacity. Given that the topsides were designed for the existing nameplate capacity and were upgraded in during the 2014 - 2015 shipyard campaign, there is the potential that increasing re-injection could lead to OIW content management issues. Santos has reviewed further debottlenecking opportunities and no single point was identified for significant improvements to reinjection capacity. Additional capacity can therefore only be achieved through a holistic upgrade to the majority of the FPSO systems. Significant rearrangement of the topsides inclusive of water reinjection and entire power and steam generation system), and is not economically feasible for this asset and in addition, there is not enough room on the FPSO to accommodate an upgrade on the all the systems. Injectivity of the wells may still decline, negating the benefit of the increased PW injection rate.	**Rejected** – It is not practicable nor feasible to further upgrade the PW reinjection. There is no remaining physical space available on the FPSO deck for the addition of additional process modules, even if there were not the current structural limitations with respect to mass and hull fatigue. Any major replacement or addition of process modules would require major facility redesign and hull structural modifications (an additional shipyard project that would take at least 12 months based on recent shipyard experience) and is not deemed feasible (Ningaloo Vision Produced Water Treatment System Study - NV-22-RP-20024)
N/A	Scenario 4 Scenario 5	Preventatively replace all water injection subsea valves/ flowlines.	Preventatively or reactively replace all water injection subsea valves/ flowlines, which may possibly prevent or delay the requirement for PW discharge to the marine environment if it resulted in increased serviceability of this system.	The subsea valve arrangement was specifically designed and constructed for field life and is not designed to be replaced. The entire XT and manifold would need to be retrieved and replaced. Injection subsea valves/ flowlines are managed in accordance with the IMMR program and currently meet the acceptance criteria. Historical use has not shown any leading indicators of failure over the operational life of the facility. There is significant cost in undertaking a well IMMR campaign to preventatively replace all injection subsea valves/ flowlines, irrespective of production loss even whilst the FPSO is off location. ($25-35 million per well) This operation involves a sequence of multiple drill rig interventions and multiple subsea construction vessels operations resulting in a conservative estimate of more than $150 million. Subsea integrity is managed through the Subsea IMMR program, and arbitrary preventative replacement in the absence of an integrity concern or failure is not considered reasonable or practical.	**Rejected** – The cost outweighs the environmental impacts, given that the historical use has not shown any leading indicators of failure over the operational life of the facility. Field economics would not support this control. There would also be additional issues and risks relate to replacement of the manifold.
N/A	Scenario 2 Scenario 3 Scenario 4	Shutdown production during temporary PW discharge to the marine environment	Will prevent PW discharge overboard.	Full production loss for up to 6 months in the event of unplanned temporary PW discharge to the marine environment events.	**Rejected** – Whilst the control may be feasible, it is not reasonably practicable due to the significant cost

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				Shut-in costs are estimated at approx. $3M/day	of lost production and only minor reduction in environmental impacts.
N/A	Scenario 2 Scenario 4	Reduce production during events which result in temporary PW discharge to the environment	Will prevent / reduce PW discharge overboard as production operations create the PW.	Reduced production results in significant cost implication (estimated at >$500,000 per day).	**Rejected** –Control may be feasible but not reasonably practicable due to significant costs of lost production and only minor reduction in environmental impacts.
N/A	Scenario 4	Preventative replacement of pump that would reduce the potential for pump serviceability issues or full failure	Preventative replacement of pump will pre-empt failures and issues which could lead to a discharge to the marine environment.	The pump module is managed in accordance with CMMS and PSAPs to meet the acceptance criteria. Replacement pre-emptive of a failure would be arbitrary and would provide little / no environmental benefit at significant cost. Historical use has not shown any leading indicators of full failure over the operational life of the facility. Two options exist to replace pump. <u>Option 1</u> – Replace pump in shipyard - estimated cost is $500k-$1 million + $7 million extended shipyard time + $7 million production loss. Total estimated cost is $15 million <u>Option 2</u> - Replace pump offshore estimated at $500k -$1 million + $14 million production loss. Total estimated cost is $15 million. A 12 month period is anticipated to replace the pump. An additional pump is also available and maintained by Santos to replace a failed pump should a failure ever occur	**Rejected** – The high cost, and time required to replace a pump, combined with the fact an additional pump is available and maintained ready to install if ever needed, outweighs only a minor reduction in environmental impacts.
N/A	Scenario 4	Preventative replacement of **all** pipework/ valves would reduce the risk of topsides valving / pipework integrity issues	Preventative replacement of all pipework/ valves will pre-empt integrity issue which could lead to a discharge to the marine environment.	The pipework/valves is managed in accordance with CMMS and PSAPs (Refer CM-04) to meet the acceptance criteria. E.g. from 2018 to 2020 a pre-shipyard inspection survey was completed on the PW system to identify PW equipment requiring pre-emptive replacement. The pipespools in the PW system were identified to be included in this replacement program, no other equipment r was identified as needing replacement as part of the comprehensive survey. It is not reasonable or practical to replace **all** the pipework/ valves because it comes at significant cost with no reduction in environmental impacts given integrity is managed under CM-04. However, two options exist: <u>Option 1</u> – Replace as part of an FPSO shipyard scope - cost is estimated at $4 million for equipment replacement + $14 million extended shipyard stay + $14 million production loss. Total estimated cost is $32 million <u>Option 2</u> - Replace as part of offshore scope - cost is estimated at $4 million equipment replacement + $21 million Production loss. Total estimated cost is - $25 million	**Rejected** – High cost and replacement risk of all pipework/ valves outweighs the environmental benefit. Pipework / valves are managed in in accordance with CMMS and PSAPs to meet the acceptance criteria, pre-emptive replacement is currently not required.

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				Additional risks with executing offshore is that spools will need to be fabricated in shorter sections (i.e. more flange connection/leak point), major construction work offshore. A 12 month period is anticipated to replace all pipework/ valves.	
N/A	Scenario 2 Scenario 4	Install additional power generation equipment to avoid need for load shedding	Installed additional power generation equipment will reduce load shedding and subsequent discharge.	There is currently insufficient deck space on the FPSO and room on the electrical switchboard to allow new power generation unit (1 x 20ft container for ~1MW) without major facility modifications or changes to cargo operations. Installation of the unit would lead to an approximate loss 20% of deck space/laydown area, which is required approximately 4-5 days a month to support normal operations, and this could cause potential safety issues in the work environment. New power generation may impact weight/class limits of the FPSO and increase fuel requirements. Additional power generation unit would require major mechanical modification to laydown area. FPSO would have to complete modifications at the shipyard.	**Rejected** – High cost and installation of a new power generation unit on the FPSO deck is not feasible. There is no remaining physical space available on the FPSO. Any major replacement or addition of power generation equipment would require major facility redesign and hull structural modifications (an additional shipyard project that would take at least 12 months based on recent shipyard experience) and is not deemed feasible (Ningaloo Vision Produced Water Treatment System Study - NV-22-RP-20024)
N/A	Scenario 2 Scenario 3 Scenario 2	Slops transfer to offtake tanker for processing at terminal	Slops transfer to offtake tanker will reduce the need for discharges as the slops tank will be available with capacity rather than having to discharge overboard.	Safety considerations of an additional tanker in field. Tanker will charge for reprocessing cost at terminal. A cost is associated with sending slops water to tankers (estimated at $100k). Also slops tank only has a limited capacity and needs to be transferred more frequently than regular offtake schedules. Offloading line would need to be used to pump PW to an offtake tanker – risking corrosion of the line and further risks.	**Rejected** – Not feasible because use of line raises potential corrosion issues with the offtake line. Furthermore, the high cost outweigh the environmental benefit and increased tanker presence in field increases safety risks.
N/A	Scenario 2 Scenario 3 Scenario 5	Provision of secondary or tertiary treatment of PW to achieve OIW of potentially less than 20 mg/L	Lower concentration of OIW would reduce PW mixing zone and subsequent impact to the marine environment. May reduce the PC99 PW mixing zone by a few hundred metres.	Technologies are potentially available to reduce OIW content but not for the temporary or permanent maximum flow rate. Additional cost involved in installation and lack of space requirement on the FPSO required. The FPSO was built to a accommodate the current PW reinjection system and is class certified for the current system. Adding tertiary treatment for PW will impact the FPSO class certification due to: + Additional weight on the FPSO + Impact to buoyancy of the FPSO + Power generation is designed for the existing pumps and nameplate Santos has screened recent upgrades implemented by other titleholders operating similar activities in the region, and concluded these solutions offer limited improvement (if any) to the existing modifications made to the PW systems made at the 2014-2015 shipyard campaign, in proportion to the cost and complexities. Major	**Rejected** – Not feasible on the NV FPSO due to lack of space and modifications were already optimised to fit within the restricted space available at shipyard in 2015. There is no remaining physical space available on the FPSO deck for the addition of additional process modules. Any major replacement or addition of process modules would require major facility redesign and hull structural modifications (an additional shipyard project that would take at least 12 months based on recent shipyard experience) and is not deemed feasible, or potentially even possible (Ningaloo Vision Produced Water Treatment System Study - NV-22-RP-20024)

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				modifications were made to the PW processing systems during the 2014 - 2015 shipyard campaign. The intent of these modifications was to increase the separation efficiency of the process and reduce OIW with good practice PW management and technology. Improvements to PW processing included: + **Measures undertaken to reduce OIW at the front end of the PW processing** + Production Separator – Upgraded internals and controls to improve separation of oil from water + Production chemical optimisation that impacts better separation that impacts better separation at all stages + **Measures undertaken to reduce OIW at the intermediate stages of the PW processing** + Hot water recycle system including heat exchangers resulting in improved separation + Degasser and flotation cell – internals resulting in improved separation + Installation of low shear pumps and control system to reduce the formation of emulsions from the gas flotation unit resulting in improved separation + **Measures undertaken to reduce OIW at the final stages of the PW processing prior to reinjection or discharge** + Installed a reject liquid tank to provide improved handling of increased oil removed from improved PW separation + Upgraded a water injection control valve to provide redundancy on injection subsea (increased reliability provided by two control valves in parallel) + Installed a third hydrocyclone sand filter (to capture sediments and improve PW polishing), which reduces the risk of clogging up a reinjection well, or sediment deposition on seabed during discharge. + Induced Gas Flotation pumps upgraded including eductor upgrades resulting in improved separation at final polishing. All these modifications came at significant time and cost and informed the 2015 NOPSEMA and DoE accepted NV EP (revision 7) to provide for overboard PW discharges which is considered ALARP and acceptable. The major modifications made in 2014-2015 during the NV shipyard campaign represent the best technical optimisation of the existing facility and further improvement in oil-water separation for the purposes of achieving PW discharge specifications / reduction of OIW content can only be achieved by process operation optimisations (Ningaloo Vision Produced Water Treatment System Study - NV-22-RP-20024). In preparation for infill drilling campaigns – and in light of the high OIW content other titleholders in the area	Significant costs due to the change in system affecting class certification and given that the additional treatment may only reduce the PW mixing zone radius by a few hundred metres. Given the relatively small PW mixing zone (refer to **Section 6.7.2.5**) and the minor impacts from PW discharge the control cost outweighs the environmental benefits.

Reference No	Applicable Scenarios	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				operating similar facilities have experienced when bringing new infill wells online – Santos proactively undertook comprehensive oil, water, and completion fluid compatibility studies. This work allowed process adjustments to occur, which ensured optimal separation of oil from water occurs when brining new wells online. This reduced the potential of high OIW occurring for short periods as new wells were brought online and will be utilised for future infill drilling campaigns. The asset has been successful to date in operating and maintaining the PW reinjection systems with a high level of reliability and haven't need to exercise a contingency discharge, avoiding impacts to the commonwealth marine area.	
N/A	Scenario 2 Scenario 3 Scenario 4 Scenario 5	Install two OIW inline analysers so if one is not functioning there is redundancy in the system	Would allow for further readings of OIW to occur if other analyser goes offline. Provides additional verification of OIW.	Cost of installing a new OIW inline analyser is high, considering that verifications of OIW already occur through laboratory analysis every 6 hours and that these are increased to every 3 hours if the OIW analyser goes offline.	**Rejected** – Verifications of OIW already occur. Additional OIW analyser provides no material reduction in environmental impacts.

6.7.4 Environmental Impact Assessment

6.7.4.1 Overview

The following scenarios (as defined in **Section 6.7.1**) resulting in a discharge of PW to the marine environment have been risk assessed below:

+ **Scenario 2**: Temporary planned discharges to the marine environment for maintenance activity purposes (with the intention to return to reinjection post maintenance activity) (**Table 6-18**);
+ **Scenario 3**: Temporary planned high oil in water discharge to the marine environment, limited to two specific events (with the intention to return to reinjection when upset condition resolved), preceded by a loss in PW injection capacity (**Table 6-19**);
+ **Scenario 4**: Temporary unplanned discharge to marine environment (with the intention to return to reinjection when upset condition resolved) (**Table 6-20**); and
+ **Scenario 5**: Permanent discharge to marine environment (**Table 6-21**).

For the purposes of the impact assessment the scenarios have been risk assessed as follows:

+ **Scenario 5:** Permanent discharge to marine environment (**Section 6.7.4.1**)
+ **Scenario 2 and 4:** Temporary planned and unplanned discharge to marine environment (**Section 6.7.4.2**)
+ **Scenario 3:** Temporary planned high oil in water discharge to the marine environment (**Section 6.7.4.3**)

6.7.4.2 Scenario 5: Permanent discharge to marine environment – Impact Assessment

Receptor	Consequence Level
Threatened / migratory/ local fauna	Minor – Permanent discharge of PW to the marine environment has the potential to result in localised impacts to water quality in the vicinity of the PW mixing zone, defined as a 459 m radius around the FPSO (refer to **Section 6.7.2.5**). A permanent discharge to the marine environment has the potential to impact water quality for the duration of the discharge. On the assumption that a permanent discharge may occur, impacts to water quality are considered to be minor. Predicted impacts to marine fauna will be less given the localised spatial extent of the PW mixing zone and the transitory nature of most marine species that may be present inside the mixing zone, whilst a discharge is occurring. Impacts to the various marine fauna are discussed below: <u>Marine Mammals</u> Eight species of whale and one dolphin species may potentially occur within the predicted PW mixing zone (**Table 3-6**). The pygmy blue whale BIA for distribution and the humpback whale migration BIA overlap the PW mixing zone. Deteriorating water quality / chemical and terrestrial discharge is recognised as a potential threat to a number of marine fauna species in relevant Recovery Plans and Conservation Advice (**Table 3-8**). The Conservation Management Plan for the Blue Whale aims to minimise anthropogenic threats to allow for blue whale conservation status to improve so that they can be removed from the EPBC Act threatened

	species list. Potential implications to this aim as a result of PW discharge to the marine environment are discussed in **Section 6.7.6**. Based on the concentrations and relative toxicity of chemicals in PW, and the predicted dispersion and biodegradation/transformation rates in the receiving waters, it is likely that there is only a limited potential for acute toxicity beyond the immediate vicinity of produced water discharges (Neff et al, 1992). The NV PW composition including toxicity profile is presented in **Appendix G**, and modelling has been performed based on the safe dilution factors. It shows that a PC99 level is reached at a 459 m radius. For marine mammals that may be exposed to the PW plume, toxic effects are considered highly unlikely since these species are mobile and therefore will not be constantly exposed for extended durations that would be required to cause any major toxic effects. Impacts will be behavioural in very close proximity to the release, if at all. Impact to populations or ecosystems are not anticipated. PAH has been mainly recorded within invertebrates which are less efficient at metabolising PAH, however, bioaccumulation within marine mammals is not anticipated given their transient nature and potential for short term exposure. The PW mixing zone overlaps the humpback whale migration BIA. Aerial surveys of the humpback northern and southern migration routes (July to October) suggest the migratory paths along the west coast of the Exmouth peninsula occur within 9 nm of the coast. The mean water depth whales were sighted in was 96 + 11m, with a maximum depth of 240 m (McCauley et al, 1999). Therefore given the water depths of the PW mixing zone (>300m), the species are unlikely to intercept the PW mixing zone during their migration. Should humpback whales may be exposed to the plume, it is not expected to interfere with their migration activity, particularly given the size of the PW mixing zone (459 m radius around the FPSO, refer to **Section 6.7.2.5**). Any impact is expected to be at individual behavioural level only, if at all. Impact to populations or ecosystems are not anticipated. The PW mixing zone also overlaps the pygmy blue whale BIA for distribution. The pygmy blue whale may transit the PW mixing zone during their Northward (May – August) and southward migration period (October-December). The pygmy blue whales tend to pass along the shelf edge at depths between 500m to 1000m during their migration (Commonwealth of Australia, 2015), which is outside the depths of the PW mixing zone (~ 300m), therefore significant numbers of the species are not expected. However, should pygmy blue whales intercept the PW mixing zone impacts are not anticipated due to their short duration of exposure, as they transit through. The transfer and accumulation of contaminants through trophic levels (known as biomagnification) is one potential pathway that could lead to higher order vertebrate consumers (e.g. marine reptiles and marine mammals, such as the humpback whale and pygmy blue whale) accumulating contaminants and suffering adverse impacts if they were to feed in the area around the NV FPSO. However, this has not been demonstrated for PAHs, which are the contaminants of most concern within the PW, and thus it is not expected that marine mammals would suffer chronic impacts if feeding on fish or invertebrates occurring around the NV FPSO. PAH metabolism is generally very efficient in fish and other vertebrates and bioaccumulation of PAH within these taxa do not generally reflect their level of exposure (van der Oost et al., 2003). In addition marine mammal food sources (e.g. krill for blue whales) have a much wider distribution than the PW mixing zone, the species will not be subject to

	feeding on the species only within the PW mixing zone, reducing potential for biomagnification. Marine Turtles Loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle and flatback turtle species are known to occur within area of the PW mixing zone (**Table 3-7**). It is possible that individual turtles may come into contact with the PW mixing zone. However considering the water depths of the PW mixing zone compared to observed water depths of internesting turtles and the lack of any reef habitat / seagrass, large numbers of the species are not expected within the mixing zone and significant impacts will not occur. In addition, marine turtles are unlikely to use the PW mixing zone for extended feeding periods , further reducing likelihood of impacts on marine turtles. Behavioural impacts may occur to a small proportion (individuals) of a local population in close proximity to the PW discharge. However the transient nature of marine turtles limits their exposure to PW and bioaccumulation is not anticipated. Impact to populations or ecosystems are not anticipated. Chemical and terrestrial discharge and marine pollution are identified as potential threats to turtles within Recovery Plan for marine turtles in Australia 2017-2027 (**Table 3-8).** Within the Recovery Plan, acute chemical and terrestrial discharge refers to any release of pollutants and/or sediment into marine turtle habitat, including spills from land sources, vessels, drilling operations, and natural sources. Detail on the acceptability of the PW in relation to the Recovery Plan objectives is detailed in **Section 6.7.6.** Benthic habitat A survey of seabed habitat has previously been conducted at the Coniston/Novara fields (RPS, 2011a) and at the Van Gogh Field (Apache, 2009). The seabed survey at the Coniston/Novara fields, along the flowlines and production manifold locations, is primarily flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (including anemones, sea stars, soft corals, crabs, shrimp and sea urchins) and an infaunal community dominated by polychaetes and crustaceans. A daily sediment deposition rate of <0.2 g/m^2 and annual sediment deposition rate of ~41 g/m^2 was predicted in the modelling (**Section 6.7.2.5**) (APASA, 2020). Sediment deposition is predicted within a few hundred metres of the discharge (APASA, 2020). Deposition annually was predicted at ~41 g/m^2 at this value there would be some measurable deposition on the seabed. However the modelling assumes no sediment re-mobilisation or natural sedimentation occurring and is considered and significantly overestimate rate of deposition. The modelled sedimentation is also at levels that are much less than natural sedimentation rates and will not result in any noticeable physical changes to the seabed. The concentrations of PAH in sediments near PW discharge sites are related to the volume and density of PW discharged, the PAH concentrations, water depth, and local mixing regime (Neff et al, 1992). Ecological impacts at the benthic population and community levels on the seafloor are most commonly on the order of 200–300 m from their source, if recorded (Neff et al, 1992). Neff et al, (1992) describes that in well-mixed offshore waters, elevated concentrations of saturated hydrocarbons and PAH in sediments may be observed out to a few hundred meters from a

	high-volume PW discharge. It should be noted however that concentrations of contaminants found are highly dependent on the receiving environment (Neff, 2005; Niu et al., 2009). Seawater and sediment samples taken around Bacia de Campos oil offshore platforms which discharge PW were analysed by Jerez Vegueria et al, 2002 in order to evaluate the environmental impact from discharges of Ba, 226Ra, 228Ra, V, Ni and Pb. A total of 21 sampling points around two platforms (Pargo and Pampo) were taken and the water quality sampling points were allocated at a distance of 250, 500 and 1000 m from the platform. The results showed that, in spite of the elevated concentrations of radium and barium in the produced water, the obtained concentrations in the seawater and sediment samples were at the local background level (Jerez Vegueria et al, 2002). Dissolved iron and manganese within PW precipitate rapidly as oxyhydroxides when the PW plume mixes with oxygen-rich receiving waters. These particulate metals tend to settle slowly out of the water column and accumulate to slightly elevated concentrations in surficial sediments around the PW discharge site (Neff, 2002; Lee et al., 2005a). Given the NV PW includes both these components (albeit in very minor concentrations, refer **Appendix G**), they may accumulate within sediments. However, the combination of elevated near-field dilution, low PW particulate concentrations (median TSS of 54.7 mg/L, Intertek, 2019b), deep waters (>340 m) and elevated currents (median of 0.2-0.3 m/s), the risk of sediment quality degradation and associated benthic impacts is considered low. It is possible that contaminants from permanent or cumulative temporary discharges of PW accumulate through sedimentation on the seabed, however this is highly unlikely due the following: + The water depths (>340 m) and elevated currents, leading to higher dispersion prior to settling + Natural sediment resuspension + Only the fine sand fraction (representing <7% of the total particulates discharge) would settle to the seabed with the silts (representing > 85% of total particulates) dispersing over a wide area at very low concentrations levels + High degradation rates of both biogenic (carbon) and hydrocarbons at the sediment interface (Burns et al 2003) As sedimentation levels or associated contamination cannot be confirmed at present on the seabed (PW has not been discharged at NV), a conservative approach was undertaken in assessment of potential effects to benthic habitat. . Given that there is potential for elevated concentrations of PW contaminants on the seabed, the consequence is determined to be Minor. It should be noted however, that increase is not expected to cause any significant impacts on benthic habitat species. Elevated concentrations of contaminant on the seabed from a PW discharge would be verified through implementation of the NV Water and Sediment Quality Monitoring and Sampling Plan (**Appendix I**). <u>Plankton</u> There is the potential for PW exposure to plankton up to a few hundred metres (refer to **Table 6-24**) away from the PW discharge location. Plankton within the predicted PW mixing zone has the potential to be

	exposed to both chronic and acute concentrations of toxicants that may result in lethal and sub lethal effects. Planktonic organisms are the most vulnerable to effects from the PW discharge as they drift freely in the water column and are unable to avoid interaction with the PW. Exposure of zooplankton to hydrocarbons for extended periods (days to weeks) has resulted in growth inhibition (Vieira and Guilhermino, 2012). Phyto- and zooplankton populations (and most fish species) have a much wider distribution than the PW mixing zone. Hence, for a significant impact to occur either harmful exposure to PW has to be sufficiently wide scale or the population influence from locally affected individuals has to be correspondingly large. Neither of these occurrences are likely, particularly given the size of the mixing zone (459 m radius around the FPSO). In addition, Hjermann et al., (2007) notes the difficulty in making reliable extrapolation to the impact at population level since effects on individuals may be masked by other factors acting on populations e.g. distribution patterns, seasonality, species interaction, density dependent functions, other stressors, and the complex and dynamic physical conditions in the offshore ecosystem. Given the PW mixing zone is within a highly dispersive open ocean environment and the relative size of the potential PW mixing zone (459 m radius around the FPSO) is insignificant compared to the surrounding oceanic waters, any impacts to plankton on a population level are expected to be negligible. Fish and Sharks Pelagic fish are commonly associated with offshore structures and therefore higher abundances are likely to occur around the NV FPSO than in surrounding open waters, especially given the water depth at discharge location is >340 m. There is the potential for pelagic fish to be exposed to PW at levels sufficient for effects to occur if they swim repeatedly or continually through the PW plume, particularly if in close proximity to the discharge location or in surface waters where the PW plume is likely to initially form. Impacts to fish are likely to be caused by exposure to PAH within the PW or heavy metals across gill structures, although impacts could also occur through ingestion of hydrocarbon droplets. PAHs are the hydrocarbon of most concern in terms of long term exposure to PW. While PAH concentrations may be elevated in fishes attracted to the NV FPSO, the elimination of PAHs is generally very efficient in fish and other vertebrates and bioaccumulation of PAH within these taxa do not generally reflect their level of exposure (van der Oost et al., 2003). The sensitivity of PW toxicity to marine organisms also varies with species, with crustaceans generally more sensitive than fish (Neff, 1987; Louisiana Department of Environmental Conservation, 1990; Jacobs and Marquenie, 1991; Terrens and Tait, 1993). Børseth and Tollefsen (2004) monitored bioaccumulation and biomarker responses in mussels (Mytilus edulis) and Atlantic cod (Gadus morhua) held in cages in the vicinity of the Troll B Platform on the Norwegian continental shelf. Cages were deployed for six weeks both inside (500 m and 1,000 m from the source) and outside the zone of expected influence of the PW plume. The following was noted:

	+ Concentrations of metals and PAH in soft tissues of the caged mussels correlated well with distance from the discharge, with highest body burdens in mussels closest to the PW discharge site. The PAH assemblage in the mussel tissues was dominated by alkyl homologues of naphthalene, phenanthrene, and dibenzothiophene, suggesting exposure to PAH from the produced water discharge. Biomarker responses in the mussels were weak, providing only equivocal evidence of exposure to produced water chemicals. + No significant difference in levels of plasma vitellogenin (an indicator of exposure to endocrine-disrupting chemicals) in male cod from exposed and reference sites. No significant differences were detected in ethoxyresorufin-o-deethylase (EROD) activity (biomarker of exposure to chemicals, including PAH) in livers of fish from exposed and reference locations, indicating little or no exposure to PAH. Similarly Førlin and Hylland (2006) measured hepatic EROD activity and bile metabolites in juvenile cod caged at several distances down-current of a PW discharge of 74,100 m^3 per day from a platforms in the Statfjord field, offshore Norway. There were no significant trends in EROD activity in male and female cod with distance from the discharge. Førlin and Hylland (2006) concluded that the cod were exposed to low levels of PAH from the produced water discharges, but exposure levels were well below those that would pose a health risk to fish living near the platforms. In a review of the environmental impacts of PW, Bakke., et al (2013) found that no indication that levels of trace metals in fish and shellfish collected close to offshore installations are significantly above natural background concentrations. It has been noted in literature that the rapid metabolism of PAH by vertebrates often provides only limited value when assessing exposure to PW contaminants, whilst bile metabolite levels in fish may provide a better assessment of the degree of PW exposure (Meier et al., 2010. Sundt et al. (2011). Meier et al., 2010). Sundt et al. (2011) and Brooks et al. (2011) detected a significant increase in bile metabolite levels of Alkylphenols (APs) in Atlantic cod caged for 6 weeks about 200 m from a North Sea PW outfall. It should be noted that although an increase in bile metabolite levels of AP was found it only provides evidence of PW exposure and not impact to the species at a population level. Both laboratory experiments and field surveys (as described above) suggest that detectable exposure as well as some impact responses can be induced in fish and mussels when these are exposed to PW in controlled situations, e.g. when they are kept within the PW plume in the water column relatively close (some hundred meters) downstream of the PW discharge point. Similar impacts have yet not been demonstrated in wild fish when they are collected in PW influenced areas (Beyer et al, 2019), the overall risk for PW discharges to induce adverse impact in populations of wild fish and possibly other pelagic organisms is low (Beyer et al, 2019). Most fish species have a much wider distribution than PW mixing zones and their potential exposure to PW constituents at hazardous levels will be short term and transient. For significant impacts to occur in a fish population, either harmful exposure to PW must be sufficiently wide scale or the population influence from locally affected individuals must be correspondingly large. Neither scenario is likely at NV, given the lack of

	field-based evidence from other facilities to demonstrate impacts. where permanent PW discharge occurs. The potential for high levels of PAH to be passed up through the food chain (biomagnification), as discussed above, from small fish to larger fish (or other vertebrate predators) is low. As pelagic fish are commonly associated with offshore structures, they could therefore be exposed to the PW mixing zone for longer periods, however given the constituents of the PW and the overall risk from PW to fish (described above), biomagnification is not anticipated. Impacts to demersal (benthic) fishes (i.e. those that comprise continental slope demersal fish communities) are not expected given any PW plume will be generally confined to surface waters with negligible settlement and accumulation of contaminants expected on the seabed. The foraging BIA for the whale shark also lies in close proximity to the PW mixing zone and other fish species may occur within the region (see **Table 3-6)**. Aggregation sites for whale sharks occur along the central and north-west coast of Western Australia from March to May and are focused at Ningaloo Reef, within the Exmouth region. This aggregation area is inshore of the impact area but transient individuals may be exposed. Impact to populations or ecosystems is not anticipated given their transient nature and short term exposure. Recovery plans and conservation advice for fish and sharks were assessed as part of this impact assessment however no potential threats that may occur as a result of PW discharge were identified. Fish and Sharks may be attracted to the FPSO for short periods, but are unlikely to be permanently exposed to PW discharge. At best, exposure will be intermittent with some avoidance behaviour likely. As sharks are opportunistic feeders, they are unlikely to permanently reside within the PW mixing zone and no population or ecosystem levels effects are expected. <u>Pelagic invertebrates</u> Pelagic invertebrates present in surface waters may be exposed to elevated concentrations of toxicants within the PW, however this is only likely if they are present at the point of discharge. Concentrations rapidly decline with distance away from the discharge point. These impacts are not expected to be significant on a population level given the small impact area compared to surrounding open ocean and the widespread distribution of pelagic invertebrates.
Physical environment/ habitat	<u>Key Ecological Features</u> The PW mixing zone overlaps the Continental Slope Demersal Fish Communities KEF. As described above, it is possible that contaminants from permanent or cumulative temporary discharges of PW could accumulate through sedimentation on the seabed, however this is highly unlikely given the water depths at the FPSO location and the currents which will aid in the rapid dispersion of particulates away from the discharge point. Less than 7% of the total particulates discharged would settle to the seabed with the bulk of the particulates dispersing over a wide area at very low concentrations levels (refer to chemical properties, **Appendix G**). Any organic matter present on the particulates that settle to the seabed will be subject to rapid degradation at the sediment interface (Burns et al. 2003) resulting in no net accumulation of contaminants on the

	seabed. As sedimentation levels or associated contamination cannot be confirmed at present (PW has not been discharged at NV), a conservative approach is to consider a physical habitat modification (sedimentation) and contamination as credible. It is therefore possible that a portion of the Continental Slope Demersal Fish Communities KEF is subject to minor sediment accumulation (assumed <0.000001% of the overall area of the KEF area which is 33,182 km^2), however this is also not credible as natural sedimentation rates in these offshore areas exceeds the modelled sedimentation. Furthermore, the portion of the KEF that overlaps the PW mixing zone is not considered an important habitat for demersal fish, given the sparse epifauna and infauna species identified in field surveys (RPS, 2011a, Apache, 2009). Impact to fish species have been reviewed extensively above. For significant impact to occur in a fish population either harmful exposure to PW must be sufficiently wide scale or the population influence from locally affected individuals must be large enough. None of these are likely from PW discharge from the NV operations. Given the transitory nature of fish species, the seabed habitat (sand, silt, mud) and the relatively small area of the PW mixing zone (assumed <0.000001% of the overall area of the KEF area which is 33,182 km^2)), PW exposure is expected to be limited to a small number of individuals which would not result in population or ecosystem level effects. However, in the event of a permanent discharge there is a potential for accumulation of contaminants on the seabed, a consequence of Minor has been conservatively assigned. It should be noted that this contamination will be monitored in accordance with the PW Adaptive Management Plan (**Appendix H**) and the NV Sampling and Monitoring Plan (**Appendix I**). The literature and modelling results (**Section 6.7.2.5**) referenced throughout this section help to understand and predict potential impacts, however the implemented ongoing monitoring program within **Appendix I** will provide further understanding of the environmental impact from PW discharge at the NV FPSO location. The sediment and water quality monitoring program (Appendix I), with the aim of determining if contaminants are above guideline levels (i.e. ANZECC/ARMCANZ, 2000, ANZG, 2018) will be initiated based on the rationale presented in **Appendix H.** Should exceedance of these outside of the PW mixing zone occur Santos will re-evaluate the acceptability and impact of the PW discharge, as per **Appendix H** (PW Adaptive Management). The acceptability of PW discharge within the Continental Slope Demersal Fish Communities KEF has been reviewed in **Section 6.7.6**.
Threatened ecological communities	Not applicable – No threatened ecological communities identified within the PW mixing zone.
Protected areas	As the discharge occurs within the Commonwealth marine area. Impacts to the values of the of the are anticipated, as described for individual receptors above. No protected areas identified within the PW mixing zone. The nearest protected areas to the PW mixing zone are: + The Ningaloo WHA – 30 km + Ningaloo AMP – 27 km + Gascoyne AMP – 28 km

	Given the distance of the PW mixing zone to these areas, the impact on the conservation values of these protected areas is not anticipated. It is recognised that these protected areas support a range of habitats and faunal groups, some of which are transient species and therefore may enter the PW mixing zone. E.g. humpback whale, pygmy blue whales. Impacts to these species are described above and is expected to be at individual behavioural level only, if at all. Given the transient nature of marine mammals and size of the PW mixing zone, biomagnification and lasting impacts on these species is not anticipated.
Socio-economic receptors	Negligible effects – Potential impacts to fishery resources (demersal fish species) are unlikely to result in changes in distribution and abundance of fish species outside the PW mixing zone.
Overall worst-case consequence	II - Minor

6.7.4.3 Scenario 2 and 4: Temporary planned and unplanned discharge to marine environment – Impact Assessment

Receptor	Consequence Level
Threatened / migratory/ local fauna Physical environment/ habitat Threatened ecological communities Protected areas Socio-economic receptors	As described in **Section 6.7.1** two scenarios exist which lead to temporary discharge to the marine environment (planned and unplanned). The potential impacts to receptors from a permanent PW discharge to the marine environment have been detailed in **Section 6.7.4.5**. Impacts from a temporary discharge have been determined to be lower than those presented in that section. Temporary discharge impacts are considered negligible and limited to the duration of discharge only. It is possible that contaminants from permanent or cumulative temporary discharges of PW accumulate through sedimentation on the seabed, however this is highly unlikely due the following: + The water depths (>340 m) and elevated currents, leading to higher dispersion prior to settling + Natural sediment resuspension + Only the fine sand fraction (representing <7% of the total particulates discharge) would settle to the seabed with the silts (representing > 85% of total particulates) dispersing over a wide area at very low concentrations levels + High degradation rates of both biogenic (carbon) and hydrocarbons at the sediment interface (Burns et al 2003) Elevated concentrations of contaminant on the seabed from a PW discharge would be verified through implementation of the NV Water and Sediment Quality Monitoring and Sampling Plan (**Appendix I**). Given the above, it possible that a portion of the Continental Slope Demersal Fish Communities KEF is subject to minor sediment accumulation (assumed <0.000001% of the overall area of the KEF area which is 33,182 km^2), albeit this will below natural sedimentation levels. The portion of the KEF that overlaps the PW mixing zone is not considered an important habitat for demersal fish, given the sparse epifauna and infauna species identified in field surveys (RPS, 2011a, Apache, 2009) and the localised area of PW sediment settlement. Significant impacts on the demersal communities within the KEF are not

	anticipated. The acceptability of discharging within the KEF has been discussed in **Section 6.7.6.** A temporary planned and unplanned PW discharge has the potential to insignificantly impact local marine fauna and physical environments and habitats. The worst-case consequence is considered to be *Negligible (I).*
Overall worst-case consequence	I – Negligible

6.7.4.4 Scenario 3: Temporary planned high oil in water discharge to the marine environment – Impact Assessment

Receptor	Consequence Level
Threatened / migratory/ local fauna Physical environment/ habitat Threatened ecological communities Protected areas Socio-economic receptors	As described in **Section 6.7.1** a scenario exists where a planned high OIW content (≤70 mg/l rolling average) may be discharged for a period of up to 7 days. Modelling has been undertaken (**Section 6.7.2.5**) and shows that the PW mixing zone (**Section 6.7.2.6**) is extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days. The potential impacts to receptors from a permanent PW discharge to the marine environment have been detailed in **Section 6.7.4.2**. Impacts from a temporary planned high OIW content (≤70 mg/l rolling average) discharge are determined to as per or lower than those presented in that section. Given high OIW is a restricted to a period of discharge for up to 7 days the impacts are considered short term and negligible, limited to the duration of discharge only. It is possible that contaminants from permanent or cumulative temporary discharges of PW accumulate through sedimentation on the seabed, however this is highly unlikely due the following: + The water depths (>340 m) and elevated currents, leading to higher dispersion prior to settling + Natural sediment resuspension + Only the fine sand fraction (representing <7% of the total particulates discharge) would settle to the seabed with the silts (representing > 85% of total particulates) dispersing over a wide area at very low concentrations levels + High degradation rates of both biogenic (carbon) and hydrocarbons at the sediment interface (Burns et al 2003) Elevated concentrations of contaminant on the seabed from a PW discharge would be verified through implementation of the NV Water and Sediment Quality Monitoring and Sampling Plan (**Appendix I**). It is possible that a portion of the Continental Slope Demersal Fish Communities KEF is subject to minor sediment accumulation (assumed <0.000001% of the overall area of the KEF area which is 33,182 km^2), albeit, as described above this will below natural sedimentation levels. The portion of the KEF that overlaps the PW mixing zone is not considered important habitat for demersal fish, given the sparse epifauna and infauna species identified in field surveys (RPS, 2011a, Apache, 2009) and the localised area of PW sediment settlement. Significant impacts on the demersal communities within the KEF are not anticipated. The acceptability of discharging within the KEF has been discussed in **Section 6.7.6.**

	Marine fauna will have limited short duration exposure to the PW plume. The PW mixing zone at the PC 99, as discussed in **Section 6.7.2** may be extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days, however would not overlap any additional BIAs and would not contact any protected areas. Impacts to marine fauna are expected to be negligible. A planned high OIW content (≤70 mg/l rolling average) for up to 7 days has the potential to lead to localised, temporary impacts to local marine fauna and physical environments and habitats. The worst-case consequence is considered to be *Negligible (I).*
Overall worst-case consequence	I – Negligible

6.7.5 Demonstration of ALARP

In order to determine if impacts are reduced to ALARP additional control measures, that have the potential to prevent or mitigate impacts from PW discharge, were considered and evaluated by environmental and operations personnel. These additional control measures and an evaluation of potential issues, costs and benefits are presented in **Section 6.7.3**.

Section 6.7.3 references the Ningaloo Vision Produced Water Treatment System Study (NV-22-RP-20024) in a number of instances, relating to deck space availability, which limits further upgrades to the PW system. The study collates and summarises the extensive work that has been undertaken over the past 12 years to reduce the environmental impact of PW from the NV FPSO to ALARP.

The main focus of work in the past has been on assuring the reliability and availability of the PW reinjection system, which when combined with the historically high fuel gas availability and oil production, has meant that no PW has been required to be discharged to the marine environment to date. A parallel effort has also been undertaken to reduce the OIW content of PW to ALARP, driven by the knowledge that PW treatment and discharge will become the main operating and economic constraint as the NV asset approaches late field life, and that there are major threats to continued operation as a result of this change. These improvement works have encompassed major process plant modifications undertaken during shipyard (referenced throughout **Section 6.7.3)** as well as operating and process chemical optimisation, and has been done specifically and deliberately in preparation for the potential need for a PW discharge to the marine environment.

The conversion of a vessel (trading oil tanker) to the NV FPSO in 2008 was a major undertaking and the addition of the required structural hull strengthening and topsides processing facilities resulted in an increase in original vessel weight from 19,741 Tons to 30,847 Tons (a ~56% increase). The FPSO conversion project sought to maximise the processing system capacity (including allowing for the PW system) within the limits of mass addition (a class certification and structural limitation) and viable deck space, both of which were critical constraints on the original conversion design. The topside modules have been intentionally distributed over the entire available deck area of the FPSO to ensure deck load stress concentration reduction, structural soundness, fatigue minimisation and vessel balance. Because of this deliberate design decision, there is no remaining physical space available on the FPSO deck for the addition of additional process modules, even if there were not the current structural limitations with respect to mass and hull fatigue on the FPSO. Any major replacement or addition of process modules would require major facility redesign and hull structural modifications (an additional shipyard project that would take at least 12 months based on recent shipyard experience) and is not deemed feasible.

With the inability to increase the size of the process equipment due the aforementioned mass and space constraints of the NV FPSO, Santos has made all possible upgrades to the PW process operations and equipment over the past decade to reduce the environmental impact of PW to ALARP. As outlined in the Ningaloo Vision Produced Water Treatment System Study - NV-22-RP-20024) there are no remaining opportunities identified which are able to reduce the OIW content of the PW below what is already possible with the current PW processing.

The below sections summarise the ALARP evaluation for the discharge scenarios detailed in **Section 6.7.1**. Santos has also developed a PW Adaptive Management Plan (**Appendix H**) which sets criteria that must be achieved prior to and during discharge to the marine environment and the response actions to be taken should the criteria not be achieved.

6.7.5.1 Scenario 1: Complete reinjection – ALARP demonstration

As outlined in **Section 6.7.1** the inforce NV EP (Rev 7) provides for a variety of overboard PW discharges but historically PW discharge and impacts to the Commonwealth Marine Area have been avoided because of:

+ the high relative oil production from the original Van Gogh wells, the Coniston and Novara developments, and Van Gogh Infill wells. As the reservoir is depleted, the hydrocarbon contacts within the reservoir will continue to decrease and the production profile from the reservoir will continue to change towards end of field life. As outlined in the original field development planning, the oil rate will naturally decline over the field's life, and the water production will increase up to nameplate capacity.
+ The historically high reliability and uptime of NV's water processing and reinjection systems (wells, subsea flowlines, PW injection and processing equipment).

100% reinjection that has been achieved by the facility to date where historical demands on the PW processing system have been comfortably within the capacity. However, future demands are expected to be at (or exceed) nameplate capacity for sustained periods of time as detailed above. As such, PW system upgrades were undertaken at the 2015 shipyard campaign to reduce OIW content and mitigate against potential reliability issues typically experienced later in field life

Complete re-injection is the ongoing preferred option unless any of the below scenarios eventuate, and that reinjection is considered ALARP on the basis that there is zero PW discharge to the marine environment.

6.7.5.2 Scenario 2: Temporary planned discharges to the marine environment for maintenance activity purposes – ALARP demonstration

Planned temporary discharges of PW to the marine environment for maintenance activity purposes may be required due to a number events, as detailed in **Table 6-18.**

Historically, the volumes of PW have been managed through re-injection and utilisation of slops capacity during the planned discharge scenario (e.g. planned maintenance) due to low water cuts. Santos will continue to manage PW in this way as far as practicable. However, it is recognised that water cut and PW volumes may not always be at a level that can be effectively managed in this way during planned discharge scenarios (e.g. PW volumes may exceed water pump capacity and cannot effectively be managed by limited slops tank capacity). The PW is therefore proposed to be managed via a discharge to the marine environment.

Planned temporary discharges to the marine environment would occur as a result of planned maintenance activities (e.g. critical assurance activities as part of PSAPs). Discharge during these events typical occurs when the PW system cannot manage the PW volumes (e.g. the PW system is in-operable, PW volumes exceed the water reinjection pump capacity) and the slops tank is unable to effectively manage the volume.

The PW system is routinely inspected, tested, and maintained in accordance with PSAPs:

+ PS-03 Hydrocarbon Containment; Risers and Pipelines (NV-00-RG-10053.03)
+ PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08).
+ PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08
+ The FPSO Planned Maintenance System (CMMS) and class certification system

Compliance with the PSAPs ensures the integrity and functioning of the water injection system and topsides produced water treatment system, and the PW equipment (including all equipment associated with the processing of PW) is maintained and operated within its design and operating parameters. The maintenance of equipment is required to avoid the occurrence of unplanned temporary or permanent discharge to the marine environment scenarios.

In addition to maintenance to protect PW systems integrity, operational management is adjusted accordingly and implemented during maintenance activities (when feasible) to reduce PW volumes discharged. For example:

+ During planned pump maintenance activities, the FPSO will only shutdown one PW re-injection pump allowing for ongoing PW injection using the remaining two re-injection pumps.
+ Utilisation of the slops tank capacity when feasible.

Table 6-29 presents a range of additional controls assessed as a means to prevent or mitigate a planned temporary discharge. These controls included:

+ Reducing or shutting down production when undertaking maintenance activities;
+ Flaring of gas to the atmosphere rather than disposing of PW to the marine environment during power shedding requirements as a result of maintenance activities. As discussed in **Table 6-29** flaring of gas to the atmosphere rather than disposing of PW to the marine environment during power shedding also contributes incrementally to Australian greenhouse emissions and decrease in the remaining estimated volume of gas within the reservoir, which is used as fuel gas. This has both has economic and environmental implications later in field life (discussed further in **Section 6.7.5.5**).
+ Increase power generation capacity on the FPSO to avoid the need for power load shedding;
+ Increase the size, or retain an available volume for PW within the slops tanks or cargo tanks; and
+ Transporting PW to shore via vessel.

Given a typical temporary unplanned discharge to the marine environment occurs for a short period only (between 1 – 5 days as outlined in **Table 6-19**) , and impact is determined as negligible (**Section 6.7.4**), costs for implementing the above grossly outweigh the reduction in environmental impacts to be achieved.

There are a number of controls which could increase the capacity or rate to re-inject PW, reduce a discharge volume or reduce the OIW content from the events detailed in **Table 6-18.** These controls are relevant in the context of their ability to mitigate the impact of the discharge when PW flow rates are above those that can be re-injected by the existing three PW reinjection pump capacity:

+ Increase capacity of existing PW reinjection systems or power generation capacity.
+ Increase slops tank capacity.
+ Installation of secondary or tertiary treatment system modules of PW to achieve OIW of less than 20 mg/L prior to discharge.
+ Drill additional reinjection well/s.

The FPSO was built to a accommodate the current PW reinjection system and power generation capacities and is class certified for the existing system. An increase in PW reinjection system capacity or addition of secondary or tertiary treatment is likely to adversely impact the FPSO class certification due to:

+ Additional weight on the FPSO.
+ Impact to stability and buoyancy of the FPSO such as pushing hull stresses beyond acceptable limits.

+ Existing power generation requirements is limited to current design demand (i.e. the existing pumps and nameplate capacity)

The critical aspect in consideration of the above controls is the very limiting fact the FPSO does not have adequate room to accommodate an upgrade of the PW reinjection system / slops tank capacity (as referenced in Ningaloo Vision Produced Water Treatment System Study (NV-22-RP-20024), summarised in **Section 6.7.5**). Significant rearrangement of the topsides would be required at significant costs which is not economically feasible for this asset at this point in the field life.

Consideration was also given to the ability to further reduce OIW content in the PW discharges. Secondary and tertiary treatment may also only reduce the PW mixing zone radius by a few hundred metres because these measures will not reduce the volume of PW, only the OIW content. Given the maximum distance to meet the PW mixing zone 99% species protection, from a ≤30mg/L discharge is 459m and the subsequent impact is considered minor with controls in place, a reduction of OIW to less than 20 mg/L will only provide marginal environmental consequence improvement. As with the above, it is not feasible on the FPSO to add further secondary or tertiary OIW treatment systems, given the lack of room on the topsides (as referenced in Ningaloo Vision Produced Water Treatment System Study (NV-22-RP-20024).

Drilling of additional re-injection wells has been discussed in **Section 6.7.5.5**.

Restricting PW discharges only to certain months of the year (e.g. outside of pygmy blue whale and humpback migration) is not feasible. Whilst planned maintenance is able to be planned or scheduled to a certain degree, it is not typically able to be planned to allow for a potential delay for a period of months to avoid marina fauna migration periods. Conducting maintenance is also required as precautionary measures to prevent a unplanned temporary or permanent discharge to the marine environment and keep the facility operating in a safe manner.

As identified in **Table 6-18**, criteria has been applied, which must be met prior to the discharge of PW to the marine environment for each event. Temporary planned discharge of PW is considered ALARP when this criteria is met, the adopted controls detailed in **Table 6-29** are implemented and the criteria within the PW Adaptive Management Plan (**Appendix H**) has been achieved.

6.7.5.3 Scenario 3: Temporary planned high oil in water discharge to the marine environment, limited to two specific events – ALARP demonstration

A planned temporary high OIW discharge to the marine environment may occur as a result of a limited number of events detailed in **Table 6-19.**

Planned temporary high OIW discharge to the marine environment could occur as a result of non-steady state operations (e.g. a well coming online, dewatering of the flowlines post cyclone reconnect) and is preceded by a loss in the reinjection capacity (e.g. well injectivity decline, as detailed in **Table 6-20** and **Table 6-21**). Discharge during these events would only occur when the PW system cannot manage the PW volumes because it is experiencing some operational or functionality issues (e.g. PW volumes exceed reinjection water pump capacity reducing what can be physically reinjected, or well injectivity capacity is affected by sand face phenomena, and the slops tank is unable to effectively manage the PW volume. The maximum duration of discharge in these potential scenarios is limited to 7 days, which is based on the estimated duration needed to resolve the event which leads to the high OIW content and discharge.

The discharge criteria, likelihood and limited situations that this event may arise (two) means that it is not credible that multiple high OIW scenarios occur one after another.

As discussed in **Table 6-29,** the PW system will be inspected, tested, and maintained in accordance with the PSAPs and the FPSO maintenance system (CMMS).

Table 6-29 presents a range of potential additional options to prevent or mitigate a temporary planned high OIW discharge. These include:

- Cutting back production / flow to minimise high OIW PW (≤70 mg/l) volumes during short term dewatering of flowlines post cyclone reconnect or shipyard return.
- Increasing the size, or retaining a contingency volume for PW within the slops tanks or cargo tanks
- Transport PW to shore via a vessel

Cutting back production and flow during post connect start up, when the FPSO is experiencing a loss in reinjection capacity, is not feasible because flowrates and temperatures within the systems are needed to drive the PW systems for efficient and stable OIW separation.

As discussed in **Table 6-29** the use of vessels to transport PW to shore presents significant costs as well as transport, land based disposal and safety implications.

As discussed in **Table 6-29**, there are a number of controls which could increase the capacity or reinjection rate to reduce a discharge volume, or reduce the OIW content from 70 mg/L down to ≤30 mg/L. However, these are likely to impact the FPSO class certification and significant rearrangement of the FPSO topsides would be required which isn't possible given the lack of space on the FPSO. Given the short duration of a potential high OIW discharge (only up to 7 days), it is determined that the costs of these modifications grossly outweigh the reduction in environmental impacts over a 7 day period, that could potentially be achieved.

Given the restricted period of 7 days, the impacts are considered short term. The PW mixing zone required to achieve 99% species protection , as discussed in **Section 6.7.2** is extended to a radius of 2,182 m around the FPSO. However, the increased PW mixing zone would not overlap any additional BIAs and would not contact any protected marine reserves.

Restricting discharge to certain months of the year (e.g. outside of pygmy blue whale and humpback migration) is not feasible and the timing for high OIW events cannot be planned (e.g. cyclone disconnect events, increased slug volumes from wells).

As identified in **Table 6-19**, criteria must be met prior discharge to the marine environment for each event. Temporary planned high OIW discharge is considered ALARP when this criteria is met, the adopted controls detailed in **Table 6-29** are implemented and the criteria within the PW Adaptive Management Plan (**Appendix H**) has been achieved.

6.7.5.4 Scenario 4: Temporary unplanned discharge to marine environment – ALARP demonstration

A unplanned temporary discharge to the marine environment may occur due to a number events detailed in **Table 6-20.**

Unplanned temporary discharge to the marine environment could occur as a result of equipment failure / PW system issues etc. In these events, PW is discharged into the marine environment until the operational issue / equipment failure is resolved.

Future management of the increasing PW volumes (as a result of higher water cut towards the end of field life) may not always be possible (refer to the discharge criteria in **Table 6-20)**. Power generation limitations requiring load shedding e.g. a situation where there is not enough available power to continue to run one or more water injection pumps is the most probable event (indicative frequency of one occurrence during the life of the EP).

Discharge to the marine environment during load shedding occurs when the PW system cannot manage the PW volumes (e.g. PW system capacity is reduced (lack of sufficient power) refer **Section 2.8.1**) and the slops tanks are unable to effectively manage the volumes. The maximum duration of discharge is based on the estimated duration to resolve a complex operational issue / critical equipment failure event, but has been estimated at not exceeding a one year (**Table 6-20**). However, the majority of identified potential events are estimated at having a duration of weeks, up to 6 months. Furthermore, the indicative estimated frequency of occurrence of such events over the life of the 5 year EP is once within 5 years (**Table 6-20**) will not exceed a year (worst case).

As discussed in **Table 6-29,** the PW system is inspected, tested, and maintained in accordance the PSAPs and the FPSO maintenance system (CMMS). Operating in accordance with these requirements aims to reduce likelihood of equipment failures. However, risk of failure cannot be eliminated. A number of other controls are in place to ensure that the PW system is operated in accordance with its design parameters, thereby reducing failure likelihood. e.g. monitoring of the PW flowline operating pressure, use of corrosion inhibitors in processing etc.

For equipment with long replacement lead time (e.g. the PW reinjection pump), Santos maintains access to a critical spare. This expedites the time to undertake the replacement, thereby reducing the volume of PW that is discharged to the marine environment. Maintaining access to more than one critical spare has been determined unnecessary given the minor nature of the environmental consequence of a temporary discharge, particularly given the failure likelihood (i.e. pumps have not failed since NV operations began. Furthermore the system is subject to critical assurance monitoring and maintenance is ongoing providing an ability to detect anomalies in pump performance and order a replacement before full failure).

Table 6-29 presents a range of additional options to prevent or mitigate a temporary unplanned PW discharge to the marine environment. These include:

+ Reducing or shutting down production.
+ Increasing the FPSO power generation capacity to avoid the need for load shedding.
+ Increase the size of or maintain an available volume for PW within the slops tanks or cargo tanks.
+ Transport PW to shore via vessel.
+ Pre-emptive replacement of equipment (e.g. pump module).

Given the most likely temporary unplanned discharge to the marine environment would only typically occur for months to a year (**Table 6-20),** and impact is determined as minor (**Section 6.7.4**), costs for implementing the above controls grossly outweigh the environment impact.

During power failure / load shedding (most likely failure), there is the requirement that power for safety critical equipment to be maintained. This means that the PW pump (s) may have to be shut down for a period, leading to a discharge to the marine environment.

As discussed in **Table 6-29**, there are a number of controls which could increase the capacity or rate to re-inject, reduce a discharge volume or OIW content, however these may impact the FPSO class certification and require significant rearrangement of the FPSO topsides (as referenced in Ningaloo Vision Produced Water Treatment System Study (NV-22-RP-20024), summarised in Section 6.7.5). Given the estimated potential duration of up to one year, it is determined that the significant impracticality of changes to the FPSO coupled with the costs of these modifications on an asset operating late in field like grossly outweigh the potential reduction in environment impacts that may be achieved.

As identified in **Table 6-20**, criteria exists which must be met prior discharge to the marine environment for each event. Temporary unplanned discharge is considered ALARP when this criteria is met, the adopted controls detailed in **Table 6-29** are implemented and the criteria within the PW Adaptive Management Plan (**Appendix H**) has been achieved.

6.7.5.5 Scenario 5: Permanent discharge to the marine environment

Permanent discharge to the marine environment may be required as a result of a number of events detailed in **Table 6-21**.

A partial or full volume permanent discharge, would be required when re-injection is permanently unavailable due to instances such as a well injectivity decline (e.g. sandface skin, or a failure in the subsea system which limits or prevents re-injection. However, it is possible that none of the events may occur and permanent PW discharge may not be required. The cost to fix these issues are unreasonable based on the economics for a late in field life asset and would result in significantly reducing or shutting down production. In some instances, and dependant on the failure, it is anticipated that PW re-injection may be unable to be either partially or fully restored.

As presented in **Figure 6-5** an Environment and Economic Feasibility Study is required as part of the permanent discharge decision process. The feasibility study will consider the situation and options to repair or remediate PW system (refer to NV-CM-49). The decision to permanently discharge is only made if it is demonstrated that:

+ it is cost prohibitive (e.g. remediation costs are grossly disproportionate to the financial net benefits of the remaining life of the asset) to remediate the event which has led to the PW discharge; and
+ that the PW discharge consequence from a permanent discharge remains, ALARP and environmental acceptable

Table 6-29 presents a range of additional options to prevent or mitigate a permanent discharge to the marine environment. These include:

+ Drilling of further re-injection wells.
+ Preventative/reactive replacement of subsea system components.
+ Preventative/reactive well intervention on reinjection well.

Drilling of a new re-injection well cost is estimated to cost $50 – 100 million and could negate a discharge of PW to the marine environment should PW reinjectivity not be restored. The cost of drilling a replacement or new reinjection well could potentially be offset by savings made through:

+ Not having to undertake long term monitoring programs estimated at < $1M per year.
+ Negating the requirement for long term ongoing OIW monitoring, and equipment calibration and maintenance.
+ Avoiding the potential for production downtime due to not meeting any of the criteria applicable to overboard discharges to the marine environment.

However, these above costs are small in comparison to the cost of drilling a new injection well. In addition, they include their own environmental risks (e.g. drill cutting deposition, oil spill risk etc.).

Drilling of a new re-injection well before an actual failure event occurring, has the potential to result in significant cost being spent with potentially little environmental benefit achieved if reinjectivity issues have not occurred in the existing reinjection wells.

Drilling of a new injection after a failure occurrence is unlikely to be economically and practically feasible due to the long lead time for subsea equipment (XTs) procurement and time taken to drill and tie in a new well (e.g. 18 – 24 months from time of failure), in addition to the high cost of subsea equipment procurement.

As discussed in **Section 2.16**, cessation of operation may occur within the life of this EP. The re-injection well may only be utilised for a short period (if at all), relatively to the overall life of the field. Therefore, drilling of a new reinjection well presents a significantly high cost with little certainty over environmental benefits.

Pre-emptively conducting a PW reinjection well intervention in an attempt to assure continued water injection capacity, has been investigated, however is not considered reasonable or practicable given the cost ($25-35 million per well) and environmental risks (e.g. associated with vessel use over subsea infrastructure, intervention discharges), particularly given that the wells have not shown any injectivity issues to date. PW injection well injectivity is monitored over time in accordance with CMMS and PSAPs (Refer CM-04), allowing for any downward trends in injectivity to be identified and investigated with the aim to restore injection capacity (e.g. through chemical treatments) where feasible, before further capacity to reinject is lost.

Similarly, the preventative replacement of the PW subsea system prior to failure occurring has been investigated, however presents significant costs. The reinjection well subsea valve arrangement is not designed to be replaced, the entire XT and manifold would require retrieval and replacement. To preventatively replace, irrespective of production loss even whilst the FPSO is off location, it is estimated to cost $25-35 million per reinjection well. Subsea integrity (including the PW subsea system) is managed through the Subsea IMMR program, and arbitrary preventative replacement in the absence of an integrity concern or failure is not considered reasonable or practical. It should also be noted that historically the system has not shown any leading indicators of failure over the operational life of the facility.

As presented in **Table 6-21**, a potential event leading to a permanent discharge scenario relates to a decrease in the remaining estimated volume of free gas within the reservoir (also referred to as gas cap). The reservoir gas cap is used as a source of fuel gas for operating the facility, with excess gas being compressed and reinjected back into the reservoir to maintain the gas cap for an ongoing fuel source for the facility. Uncertainty in the remaining gas cap volume estimates indicate a need for gas conservation measures, which include reducing gas flaring to ensure fuel gas is available to be compressed and reinjected for the remainder of the assets economic field life. In the event of fuel gas shortages towards the end of field life there is the potential for the use of MDO as a substitute for providing power to the facility. However, this is challenging to the economics of the asset (e.g. transport costs, purchase cost), and presents additional environmental impacts through increased GHG emissions, once MDO is combusted, compared to fuel gas use. In a fuel gas shortage scenario, ongoing full PW reinjection may no longer be economically feasible for the asset, due to the volume of fuel gas it requires to power the PW re-injection pumps compared to powering the system to discharge PW overboard. This power is better utilised to conserve gas (e.g. through gas compression and re-injection).

Prioritisation of gas compression and re-injection to conserve gas, over PW reinjection is required to ensure the asset remains economically viable. Some of the temporary PW discharge scenarios (Scenarios. 2 and 3, refer Table 6 18 and Table 6 20 respectively) along with gas production / gas reinjection optimisation help mitigate the risk of ongoing PW permanent discharge in the future by limiting gas flaring in the short to medium term. These measures represent an opportunity to delay the potential fuel gas shortage and subsequent permanent PW discharge scenario as far as possible into the future, representing a pre-emptive ALARP approach.

As demonstrated by the PW modelling (**Section 6.7.2.5**), the distance to meet the PW mixing zone 99% species protection level from a 30 mg/L discharge is 459 m. Impacts will be monitored through a comprehensive field sampling and monitoring program as detailed in **Appendix I**.

As identified in **Table 6-21**, criteria exists which must be met prior to a permanent discharge to the marine environment. Permanent discharge is considered ALARP when this criteria is met, the adopted controls detailed in **Table 6-29** are implemented and the criteria within the PW Adaptive Management Plan (**Appendix H**) has been achieved.

6.7.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum PW discharge to the marine environment consequence is rated II (Minor)
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes - Activity evaluated in accordance with the Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and	Yes – Management is consistent with:

conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	+ ANZECC/ARMCANZ guidelines (2000). The ANZG (2018) guidelines similarly provide guidance that levels of protection should be identified, based on the environmental values to be protected + The Monitoring and Management strategy aligns to the levels of protection described by the ANZECC/ARMCANZ (2000) and ANZG (2018) guidelines. Activity in accordance with EPBC approval conditions (EPBC 2007/3213). Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities (**Table 3-3**) including the Ningaloo WHA. + Recovery Plan for Marine Turtles in Australia: 2017-2027 + Conservation Management Plan for the Blue Whale (2015-2025) The nearest protected areas to the PW mixing zone are: + The Ningaloo WHA – 30 km + Ningaloo AMP – 27 km + Gascoyne AMP – 28 km Given the distance of the PW mixing zone from a 30 mg/l discharge (and the extended PW mixing zone from a 70 mg/l discharge) (refer to **Section 6.7.2.6**) to these areas, the impact on the conservation values of these protected areas is not anticipated
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes –Cape Conservation Group (CCG) raised a number of matters in relation to the NV EP revision and PW discharges (**Section 4.4**). Control measures and associated environment performance standards are included (**Section 6.7.3** and **Table 8-2**) to address stakeholder concerns
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

PW discharge to the marine environment is not expected to significantly impact the receiving environment with control measures proposed, including compliance to the PW Adaptive Management Plan (**Appendix H**) and the criteria to discharged to the marine environment detailed within it. The below defines the acceptability for each of the discharge scenarios defined in **Section 6.7.1**.

As noted in the literature, the spatial footprint PW discharge to the marine environment varies with the volume of discharge, depth of discharge, local hydrography, particle size distribution, rates of settlement and formation water chemistry, and time since discharge (Neff, 2005; Niu et al., 2009). Modelling can provides a useful tool to predict the potential impacts from the discharge of PW to the marine environment. Santos consider that the PW discharge is acceptable based on a body of literature showing that the PW discharges generally have a very small exposure footprints (limited to a few hundred metres) and any significant impacts at population levels are not anticipated (see **Section 6.7.4**). To put the size of the PW mixing zone into context relative to the size of the BIAs, the percentage of each BIA covered by the PW mixing zone is presented below:

Table 6-30: Percent of BIA Covered by PW Mixing Zone

BIA	Percentage (%) covered by the PW mixing zone	
	≤30 mg/l	≤70 mg/l
Humpback whale migration	0.00020	0.0052
Pygmy blue whale distribution	0.00004	0.0010
Pygmy blue whale migration	0.00007	0.0016

It is recognised, that the PW mixing zone cannot be confirmed until the monitoring of the PW discharge at NV occurs. As such, a sampling and monitoring program has been developed (Appendix I)), which provides sampling frequencies, protocols and methods to be implemented.

The below Sections, provide acceptability criteria for each of the PW discharge scenarios described in Section 6.7.1.

Temporary planned and unplanned discharge to marine environment (Scenarios 2 and 4)

Is acceptable when:

+ The discharge and associated impact on the values of the Commonwealth marine area and ecological integrity of species within the water column is temporary, with the intention to return to reinjection.
+ Ecological integrity of the Commonwealth marine area is maintained by protecting 99 percent of species (PC99 (based on ANZG 2018) for water quality) outside the PW mixing zone boundary (determined to be 459 m from the FPSO), as determined through monitoring / model validation at frequencies defined in the PW Adaptive Management Plan (**Appendix H**).
+ Ecological integrity of the Commonwealth marine area is maintained by ensuring sediment quality ANZG (2018) guideline values are not exceeded outside the PW mixing zone boundary (determined to be 459 m from the FPSO) (as determined by sediment monitoring at frequencies defined in the PW Adaptive Management Plan (**Appendix H**)).
+ The discharge criteria within **Table 6-18** (planned) and **Table 6-20** (unplanned) is met.
+ The controls identified in **Section 6.7.3** are implemented.
+ The PW Adaptive Management Plan (**Appendix H**) monitoring requirements and adaptive management measures are met.

Temporary planned high oil in water discharge to the marine environment (Scenario 3)

Is acceptable when:

+ The discharge and associated impact on the values of the Commonwealth marine area and ecological integrity of species within the water column does not exceed 7 days

- Ecological integrity of the Commonwealth marine area is maintained by protecting 99 percent of species (PC99 (based on ANZG 2018) for water quality) outside the PW mixing zone boundary (determined to be 2,182 m from the FPSO for a 70 mg/l OIW discharge), as determined through monitoring / model validation at frequencies defined in the PW Adaptive Management Plan (**Appendix H**)
- Ecological integrity of the Commonwealth marine area is maintained by ensuring sediment quality ANZG (2018) guideline values are not exceeded outside the PW mixing zone boundary (determined to be 459 m from the FPSO) (as determined by sediment monitoring at frequencies defined in the PW Adaptive Management Plan (**Appendix H**))
- The PW Adaptive Management Plan (**Appendix H**) monitoring requirements and adaptive management measures are met
- The discharge criteria within **Table 6-19** is met

<u>Permanent discharge to marine environment (Scenario 5)</u>

Is acceptable when:

- Ecological integrity of the Commonwealth marine area is maintained by protecting 99 percent of species (PC99 (based on ANZG 2018) for water quality) outside the PW mixing zone boundary (determined to be 459 m from the FPSO), as determined through monitoring / model validation at frequencies defined in the PW Adaptive Management Plan (**Appendix H**)
- Ecological integrity of the Commonwealth marine area is maintained by ensuring sediment quality ANZG (2018) guideline values are not exceeded outside the PW mixing zone boundary (determined to be 459 m from the FPSO) (as determined by sediment monitoring at frequencies defined in the PW Adaptive Management Plan (**Appendix H**))
- The discharge criteria within **Table 6-21** are met
- The controls identified in **Section 6.7.3** are implemented
- An Environment and Economic Feasibility Study is completed (refer to NV-CM-49) which demonstrates that it is cost prohibitive (e.g. remediation costs are grossly disproportionate the financial net benefits of the remaining life of the asset) to remediate the event which has led to the PW discharge and that the PW discharge consequence from a permanent discharge remains , ALARP and environmentally acceptable
- The PW Adaptive Management Plan (**Appendix H**) monitoring requirements and adaptive management measures are met

The NV Operations are consistent with the relevant actions described in the Recovery Plans and Conservation Advice listed and no impacts to AMPs or the Ningaloo WHA values are expected. The specific acceptability of a discharge to the marine environment in relation to the Conservation Management Plan for the Blue Whale (2015-2025) and the Continental Slope Demersal Fish Communities KEF has been detailed below:

<u>Acceptability in relation to the aims of the Conservation Management Plan for the Blue Whale (2015-2025)</u>

The pygmy blue whale BIA for distribution overlaps the PW mixing zone and therefore the Conservation Management Plan for the Blue Whale (2015-2025) recovery objective and interim objectives are considered as part of the consideration of the acceptability of PW discharge to the marine environment. The recovery objective within the Conservation Management Plan is ‘to secure the long-term recovery objective for blue whales is to minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list’. Acknowledging that the long-term recovery objective is unlikely to be achieved over the ten year period of Conservation Management Plan, the following interim recovery objectives have been set within it:

1. The conservation status of blue whale populations is assessed using efficient and robust methodology;
2. The spatial and temporal distribution, identification of BIAs, and population structure of blue whales in Australian waters is described;
3. Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place; and
4. Anthropogenic threats are demonstrably minimised.

The highest rated anthropogenic threats are defined in the Conservation Management Plan as whaling, climate variability and change, noise interference and vessel disturbance. Although PW discharge is not explicitly mentioned as a threat within the Conservation Management Plan, reference is made to accumulation of substances in blue whales and the potential for biomagnification to occur. As detailed in the Conservation Management Plan, blue whales feed directly on krill, which occupy a low level on the food chain, and therefore biomagnification in general would not be expected to have a strong effect on blue whales since there are fewer levels in their food chain. However, pollutants remain a threat because of the long life history of blue whales and the characteristic of pollutants to accumulate in fat such as whale blubber. Biomagnification effects from a discharge of PW to the marine environment are discussed in **Section 6.7.2.2** and **6.7.4**. It is recognised that biomagnification is one potential pathway that could lead to higher order vertebrate consumers impacts. However, this has not been demonstrated for PAHs, which are the contaminants of most concern within the PW. PAH metabolism is generally very efficient in fish and other vertebrates and bioaccumulation of PAH within these taxa and do not generally reflect their level of exposure (van der Oost et al., 2003). Krill have a much wider distribution than the PW mixing zone, blue whales will not be subject to feeding on the krill only within the PW mixing zone, reducing potential for biomagnification. As pygmy blue whale are unlikely to use the PW mixing zone for extended feeding periods (particularly given its size at 30 mg/L 24-hour rolling average OIW limit is 459 m radius around the FPSO, which is extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days during a 70 mg/l discharge), biomagnification potential is further reduced.

Two targets are made within the Conservation Management Plan in relation to the Interim Objective 4 (Anthropogenic threat minimisation):

+ Target 4–1: Robust and adaptive management regimes leading to a reduction in anthropogenic threats to Australian blue whales are in place.
+ Target 4–2: Management decisions are supported by high quality information and high priority research projects identified in this plan are achieved or underway.

Santos consider **Target 4-1** to be directly related to the discharge of PW to the marine environment and has undertaken the following to achieve this target:

+ A robust ALARP assessment involving the consideration of the various controls, and those which have been adopted to manage, reduce or mitigate PW discharge to the marine environment has been presented in this EP (**Section 6.7.5**). This includes investigating PW discharge outside of sensitive marine fauna migration periods (the pygmy blue whale migration periods.
+ Criteria has been developed, which must be met prior discharge to the marine environment for each event (as identified in **Section 6.7.1**). Discharge to the marine environment is considered acceptable when this criterion is met.
+ A PW Adaptive Management Plan (**Appendix H**) has been developed which provides adaptive management measures should any criteria for discharge to the marine environment not be maintained during discharge. A monitoring plan has also been developed which contains details of the water and sediment monitoring to be conducted prior to and during a discharge to the marine environment (**Appendix I**).

- The EPO set in **Section 6.7.3** for the overboard discharge of PW is in accordance with Target 4–1 of the Conservation Management Plan. The EPO sets Santos the objective of achieving a species protection level of PC99 in the marine environment outside the defined PW mixing zone boundary. The PW mixing zone from discharges at 30 mg/l on a 24 hour rolling average, is limited therefore to a radius of 459 m around the FPSO (extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days during a 70 mg/l discharge), which represents very minor percentage of the overall distribution BIA.
- A robust PW sampling and monitoring program (**Appendix I**) has been developed which will provide assurance that the species protection level of PC99 in the marine environment is achieved outside the defined PW mixing zone boundary.

Given the above is in accordance with the Target 4-1 of the Conservation Management Plan and the pygmy blue whale are unlikely to use the PW mixing zone for extended feeding periods (particularly given its size, 459 m radius around the FPSO, extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days during a 70 mg/l discharge), the discharge of PW is not inconsistent with the Conservation Management Plan for the Blue Whale (2015-2025) recovery objectives and targets, therefore is determined the impacts from discharge of PW are acceptable.

<u>Acceptability in relation to the Continental Slope Demersal Fish Communities KEF</u>

This species assemblage is recognised as a KEF because of its biodiversity values, including high levels of endemism. A loss of benthic habitat along the continental slope at depths known to support demersal fish communities may lead to a decline in species richness, diversity and endemism associated with this feature (DoEE, 2012), however a loss of habitat from a PW discharge is highly unlikely. As detailed in the Marine bioregional plan for the North-west Marine Region, generally, most actions occurring within the Continental Slope Demersal Fish Communities are unlikely to impact adversely on the biodiversity values of the KEF. However, a number of pressures of potential concern on the biodiversity values of the KEF have been identified:

- physical habitat modification as a result of fishing gear (active and derelict)
- bycatch from commercial fishing
- ocean acidification and changes in sea temperatures as a result of climate change

It is possible that contaminants from permanent or cumulative temporary discharges of PW accumulate through sedimentation on the seabed, however this is highly unlikely given the water depths and currents will result in dispersion of the sediments prior to sedimentation occurring, and the contaminants in the PW are low levels (refer to chemical properties, **Appendix G**). As sedimentation levels or associated contamination cannot be confirmed at present (PW has not been discharged at NV), a conservative approach is to consider a physical habitat modification (sedimentation and associated contamination) on the KEF as credible. The seabed over the PW mixing zone, may harbour bacteria and fauna which the demersal fish may feed on, however large assemblages of demersal fish are unlikely, given the habitat surveys of the Coniston/Novara fields reveal a flat soft sediment habitat comprising sand, silt and mud (RPS, 2011a, Apache, 2009). The discharge of PW to the marine environment is acceptable given the size of the PW mixing zone in comparison to the overall KEF area (<0.000001%). The implementation of monitoring in accordance with the PW Adaptive Management Plan (**Appendix H**) and the NV PW Sampling and Monitoring Plan (**Appendix I**) will identify exceedance of the ANZG (2018) PC99 levels within the sediments of the KEF. Should exceedance of these outside of the PW mixing zone Santos will re-evaluate the acceptability of the PW discharge on the KEF as per the requirements of the Adaptive Management Plan (**Appendix H)**.

<u>Acceptability in relation to the Recovery Plan for Marine Turtles in Australia 2017-2027</u>

The Recovery Plan for Marine Turtles in Australia 2017-2027 objective is to minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list. Interim Objective 3: Anthropogenic threats are demonstrably minimised, is applicable to the discharge of PW to the marine environment and the following targets are made within the Recovery Plan:

- Target 3.1: Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place.
- Target 3.2: Threat mitigation strategies are supported by high quality information

The Recovery Plan details a number of anthropogenic threats to marine turtles, one being 'chemical and terrestrial discharge' which refers to any release of pollutants and/or sediment into marine turtle habitat, including spills from land sources, vessels, drilling operations, and natural sources. The Recovery Plan details the effect of some of these discharges on marine turtles as having direct impact on the species (e.g. toxicity impacts) and habitat degradation (e.g. loss of seagrass habitats). Whilst the discharge of PW does constitute as an anthropogenic discharge to the marine environment, discharging at ≤30 mg/l OIW content and ≤ 70 mg/l (less than 7 days discharge) will not lead to impacts due to:

- The environment and habitat present in the PW mixing zone is not conducive of where marine turtles are typically observed. E.g. The water depths of the operational area PW mixing zone compared to observed water depths of internesting turtles, the lack of any reef habitat / seagrass in the PW mixing zone.
- Transient nature of the species E.g. Marine turtles are unlikely to use the PW mixing zone for extended feeding periods (particularly given its size, 459 m radius around the FPSO, extended to a radius of 2,182 m around the FPSO, for a period of up to 7 days during a ≤70 mg/l discharge), further reducing likelihood of impacts.
- PAH (contaminant within PW) is generally efficient in vertebrates, bioaccumulation of PAH within these taxa do not generally reflect their level of exposure (van der Oost et al., 2003).
- Research has not documented effects of PW discharges on population and community levels (Bakke et al,. 2013).

Given the above and the Adaptive Management Pan (**Appendix H**) which ensures the impacts from PW discharges are acceptable, the discharge of PW is determined to not be inconsistent with the objectives and targets of the Recovery Plan for Marine Turtles in Australia 2017-2027.

6.8 Spill Response Operations

The spill response strategies that may be adopted in the event of a hydrocarbon spill have been identified in the OPEP. Potential impacts arising from the implementation of the following spill response operations/actions have been assessed as planned events in this section.

6.8.1 Description of Event

Event	In the event of a hydrocarbon spill, response strategies will be implemented where possible to reduce environmental impacts to ALARP. The selection of strategies will be undertaken through the Net Environmental Benefit Analysis (NEBA) process, outlined in the NV Operations OPEP (TV-00-RI-00003.02). Spill response will be under the direction of the relevant Control Agency, as defined within the OPEP (**Section 2.2**), which may be Santos and/or another agency. In all instances, Santos will undertake a 'first-strike' spill response and will act as the Control Agency until the designated Control Agency assumes control. The response strategies deemed appropriate for the worst-case oil spill scenarios identified for the NV Operations are detailed in the NV Operations OPEP (TV-00-RI-00003.02) and comprise: + Source control; + Monitor and evaluate (includes operational monitoring);

	+ Containment and recovery; + Mechanical dispersion; + Surface chemical dispersant application; + Protection and deflection; + Shoreline clean-up; + OWR; + Waste management; and + Scientific monitoring. While response strategies are intended to reduce the environmental consequences of a hydrocarbon spill, poorly planned and coordinated response activities can result in a lack of, or inadequate information being available, upon which poor decisions can be made, exacerbating or causing further environmental harm. An inadequate level of training and guidance during the implementation of spill response strategies can also result in environmental harm over and above that already caused by the spill. The greatest potential for impacts additional to those described for routine operations is from shoreline clean-up and oiled wildlife response operations where coastal and shoreline habitat damage and fauna disturbance may occur.
Extent	Extent of spill area.
Duration	Until termination criteria are met.

6.8.2 Nature and Scale of Environmental Impacts

Light emissions	
Spill response activities will involve the use of vessels which are required at a minimum to display navigational lighting. Vessels may operate near shoreline areas during spill response activities. Spill response activities will also involve onshore operations including the use of vehicles and temporary camps which may require lighting.	
Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Protected Areas Socio-Economic Receptors
Lighting may cause behavioural changes to fish and sharks, birds and marine turtles which can have a heightened consequence during key life-cycle activities, for example turtle nesting and hatching. Turtles and birds, which includes threatened and migratory fauna (**Section 3.2.4**), have been identified as key fauna susceptible to lighting impacts during spill response activities. **Section 6.2** provides further detail on the nature of impacts to fish and sharks, birds and marine turtles. Spill response activities which require lighting may take place in protected areas important to turtles, for example shoreline locations of the Montebello Islands and Ningaloo area are seasonally important for turtles. During nesting and hatching season (primarily over summer months) lighting may cause behavioural impacts to turtles including aborted nesting attempts and mis-orientation of newly hatched turtles which may increase mortality rates. Spill response activities may also occur on shorelines used by nesting and feeding birds including seabirds and shorebirds. Lighting can cause disorientation in flying birds, disrupting nesting and breeding behaviours and impact on the ability of birds to forage. Disturbance to feeding migratory	

shorebirds may reduce their ability to replenish energy reserves and alter the timing and success of migratory flights. Because of impacts to fauna, lighting has the potential to impact supported industries such as tourism and indirect impacts on the values of protected areas.		
Acoustic Disturbance		
Spill response activities will involve the use of aircraft and vessels which will generate noise both offshore and in proximity to sensitive receptors in coastal areas. Spill response activities will also involve the use of equipment on coastal areas during clean-up of shorelines (e.g. pumps and vehicles), for accessing shoreline areas (e.g. vehicles) and for supporting temporary camps (e.g. diesel generators).		
Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Protected Areas Socio-Economic Receptors	
Underwater noise from the use of vessels may impact marine fauna, such as fish and sharks, marine reptiles and marine mammals in the worst instance causing physical injury to hearing organs, but more likely causing short-term behavioural changes which may impact key life-cycle process (e.g. spawning, breeding, calving). Underwater noise can also mask communication or echolocation used by cetaceans. **Section 7.2** provides further detail on these impacts from vessels. Cetaceans have been identified as the key concern for vessel noise within the EMBA. Spill response activities using vessels have the potential to impact fauna in protected areas, this includes the Montebello Marine Park. Noise and vibration from terrestrial activities on shorelines has the potential to cause behavioural disturbance to coastal fauna including protected and migratory species of shorebirds and turtles. Shoreline activities involving the use of noise generating equipment may take place in important nesting areas for turtles and/or roosting/feeding areas for shorebirds. Because of impacts to fauna (including shorebirds, marine mammals, fish and sharks), noise has the potential to impact supported industries such as tourism and commercial fishing.		
Atmospheric Emissions		
The use of fuels to power vessel engines, generators and mobile equipment used during spill response activities will result in emissions of GHG such as CO_2, CH_4 and N_2O, along with non-GHG such as SO_x and NO_x. Emissions will result in localised decrease in air quality.		
Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Physical Environment/habitat Protected Areas Socio-Economic Receptors	
Atmospheric emissions from spill response equipment will be localised and while there is potential for fauna and flora impacts, the use of mobile equipment, vessels and vehicles is not considered to create emissions on a scale where noticeable impacts would be predicted. Emissions may occur in protected areas and/or areas where tourism is important however the scale of the impact relative to potential oil spill impacts is not considered great.		
Operational Discharges and Waste		
Operational discharges include those routine discharges from vessels used during spill response which may include: + Deck drainage;		

+ Putrescible waste and sewage; + Cooling water from operation of engines; + Bilge water; + Ballast water; and + Brine discharge. In addition, there are specific spill response discharges and waste creation that may occur, including: + Cleaning of oily equipment/vessels and vehicles; + Flushing water for the cleaning of shoreline habitats; + Sewage/putrescible and municipal waste at camp areas; and + Creation, storage and transport of oily waste and contaminated organics.	
Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Physical Environment/habitat Protected Areas Socio-Economic Receptors
Operational discharges from vessels may create a localised and temporary reduction in marine water quality. Effects include nutrient enrichment, toxicity, turbidity, temperature and salinity increases as detailed in **Section 6.4**. These may impact a different set of receptors than previously described in that section given vessel use may occur in shallower coastal waters during spill response activities. Discharge could potentially occur adjacent to marine habitats such as corals, seagrass, macroalgae, and in protected areas (i.e. receptors anywhere within the EMBA), which support a more diverse faunal community, however discharges will be very localised and temporary. Cleaning of oil contaminated equipment, vehicles and vessels, has the potential to spread oil from contaminated areas to those area not impacted by a spill, potentially spreading the impact area and moving oil into a more sensitive environment. Flushing of oil from shoreline habitats is a clean-up technique designed to remove oil from the receptor that has been oiled and remobilise back into the marine environment and result in further dispersion of the oil. The process of flushing has the potential to physically damage shoreline receptors such as mangroves and rocky shoreline communities, increase levels of erosion, and create an additional, and potentially higher, level of impact than if the habitat was left to bio-remediate. Sewage, putrescible and municipal waste will be generated from onshore activities at temporary camps which may include toilet and washing facilities. These wastes have the potential to attract fauna, impact habitats, flora and fauna and reduce the aesthetic value the environment areas, which may be within protected areas. The creation, storage and transport of oily waste and contaminated organics has the potential to spread impacts of oil to areas, habitats and fauna not previously contaminated.	
Physical Presence and Disturbance	
The movement and operation of vessels, vehicles, personnel and equipment and the set-up of temporary camp areas during spill response activities has the potential to disturb the physical environment and marine/coastal habitats and fauna, which may include those habitats and fauna within protected areas. Disturbance may also impact cultural values of an area. The movement of vessels could potentially introduce invasive marine species attached as biofouling to nearshore areas, while vehicle and equipment movement could spread non-indigenous flora and fauna. Oiled wildlife response activities may involve deliberate disturbance (hazing), capture, handling, cleaning, rehabilitation and release of wildlife which could lead to additional impacts to wildlife.	

Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Physical Environment/habitat Protected Areas Socio-Economic Receptors

The use of vessels may disturb benthic habitats in coastal waters including corals, seagrass, macroalgae and mangroves. Impacts to habitats from vessels include damage through the deployment of anchor/chain, nearshore booms and grounding. Vessel use in shallow coastal waters also increases the chance of contact or physical disturbance with marine megafauna such as turtles and dugongs. Booms create a physical barrier on the surface waters that has the potential to injure or entangle passing marine fauna that are either surface breathing or feeding.

Vehicles, equipment and personnel used during shoreline response activities have the potential to damage coastal habitats such as dune vegetation, mangroves and habitats important to threatened and migratory fauna including nests of turtles and birds and bird roosting/feeding areas. Shoreline clean-up may involve the physical removal of substrates that could cause impact to habitats and coastal hydrodynamics and alter erosion/accretion rates.

The presence of camp areas, although relatively short-term may disrupt normal behaviour of coastal species such as shorebirds and turtles and could potentially interfere with nesting and feeding behaviours.

Oiled wildlife response may include the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling such as birds and marine turtles. While oiled wildlife response is aimed at having a net benefit, poor response can potentially create additional stress and exacerbate impacts from oiling, interfering with life-cycle processes, hampering recovery and in the worst instance increasing levels of mortality. Impacts and risks from invasive marine species are described in **Section 7.1** and are not described further in this section.

Impacts from invasive terrestrial species are similar in that the invasive species can out-compete local species (e.g. weeds) and interfere with ecosystem processes. Non-native species may be transported attached to equipment, vehicles and clothing. Such an introduction would be especially detrimental to wilderness areas or protected terrestrial reserves which may have a relatively undisturbed flora and fauna community.

The disturbance to marine and coastal natural habitat, as well as the potential for disruption to culturally sensitive areas, which may occur in specially protected areas, may have flow on impacts to socio-economic values and industry (e.g. tourism, fisheries).

Chemical Dispersant Application

The application of chemical dispersants has the aim of enhancing oil dispersion and entrainment into the water column, thereby avoiding or reducing the volume of oil that could reach the shoreline. By entraining oil into the water column, chemical dispersants can aid the natural processes of biodegradation but can also increase impacts to subsea receptors through an increase in concentration and exposure of entrained hydrocarbon and dissolved oil components

Potential receptors:	Fauna (including Threatened/ Migratory/ Local Fauna) Physical Environment/habitat Protected Areas Socio-Economic Receptors

While the aim of chemical dispersants is to provide a net benefit to the environment, the use of dispersants has the potential increase the impact to receptors under the sea surface, including coral, seagrass and macroalgae, by increasing entrained hydrocarbon and dissolved aromatic hydrocarbon concentration. These sensitive receptors are generally located in shallow coastal areas of the mainland and offshore islands.

Increased entrained and aromatic hydrocarbon concentrations may also impact on marine fauna either directly or through impacts to subsea habitats. Direct impacts are most likely to be encountered by filter feeding invertebrates, fish and sharks. Fish and sharks include threatened/migratory species, which may ingest oil or uptake toxic compounds across gill structures. As a result of increased impact to marine fauna and subtidal habitats, including those that represent values of protected areas, socio-economic impacts may be felt through industries such as tourism and commercial fishing. Dispersant efficacy testing results are presented in the NV Operations OPEP (TV-00-RI-00003.02).
Disruption to Other Users of Marine and Coastal Areas and Townships
Spill response activities may involve the use of vessels, equipment and vehicles, and the establishment of temporary camps, in areas used by the general public or industry. The mobilisation of spill response personnel into an affected area may also place increased demands on local accommodation and other businesses.
Potential receptors: Socio-Economic Receptors
The use of vessels in the nearshore and offshore environment and the undertaking of spill response activities at shoreline locations may exclude general public and industry use of the affected environment. As well as impacting leisure activities of the general public this may impact on revenue with respect to industries such as tourism and commercial fishing. The mobilisation of personnel to small communities has the potential to affect the local community through demands on local accommodation and business, reducing the availability of services to members of the public.

6.8.3 Environmental Performance and Control Measures

Environmental Performance Outcomes (EPOs), control measures, Environmental Performance Standards (EPSs) and measurement criteria for spill preparedness and response activities are outlined within the relevant strategy sections of the OPEP. Control measures relevant to reducing the potential impacts from spill response operations are shown in **Table 6-31**.

Table 6-31: Reducing Potential Impacts from Spill Response Operations

Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Competent Incident Management Team (IMT) and oil spill responder personnel.	Ensures that spill response strategy selection and operational activities consider the potential for additional environmental impacts.	Personnel and operational costs associated with maintaining competent IMT team and responder personnel.	**Adopted –** Considered a standard spill response control.
Use of competent vessel crew and personnel.	Reduces potential for environmental impacts from vessel usage.	Personnel and operational costs associated with maintaining contracts with competent vessel crew and personnel.	**Adopted –** Considered a standard spill response control.

Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Acoustic Disturbance			
Vessels and aircraft compliant with the Santos Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003).	Reduces potential for behavioural disturbance to cetaceans.	No cost/issue associated with this control measure	**Adopted –**Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).
Light Emissions			
Select temporary base camps in consultation with DoT and DBCA.	Reduce coastal habitat and fauna disturbance.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control to be adopted by the relevant Control Agency.
Atmospheric Emission			
If required under MARPOL, vessels will maintain a current International Air Pollution Prevention (IAPP) Certificate	Reduces level of air quality impacts.	Personnel and operational costs associated with maintaining Air Pollution Certificate.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Disruption to Other Marine Users			
Stakeholder consultation	Promotes awareness and reduces potential impacts from response to socio-economic activities	Minimal cost in relation to overall effort/costs in managing incident	**Adopted –** Considered a standard control for incident management
Operational Discharges and Waste			
Vessels meet applicable MARPOL and Marine Park sewage disposal requirements	Reduces potential for water quality impacts.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Vessel meet applicable MARPOL requirements for oily water (bilge) discharges	Reduces potential for water quality impacts.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard spill response control (regulatory requirement).

Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Approved oily water decanting	Reduces impact from discharge of oily water from storage. Frees up space in liquid waste containers to allow further waste collection.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Compliance with controlled waste, unauthorised discharge and landfill regulations.	Ensures correct handling and disposal of oily wastes.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Physical Presence and Disturbance			
Spill response activities selected on basis of a net environmental benefit analysis.	Provides a systematic and repeatable process for evaluating strategies with net least environmental impact.	No cost/issue associated with this control measure	**Adopted –** Considered a standard spill response control.
Vessels and aircraft compliant with the Santos Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003).	Reduces potential for behavioural disturbance to cetaceans.	No cost/issue associated with this control measure	**Adopted –** Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).
Use of shallow draft vessels for shoreline and nearshore operations.	Reduce seabed and shoreline disturbance.	Operational costs associated with operating shallow draft vessels for shoreline and nearshore operations.	**Adopted –** Considered a standard control.
OSR Team Leader assesses and selects vehicles appropriate to shoreline conditions.	Reduce coastal habitat and fauna disturbance.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control.
Conduct shoreline, nearshore habitat, bathymetry assessment.	Reduce shoreline habitat disturbance.	Operational costs associated with conducting shoreline nearshore habitat assessment.	**Adopted –** Considered a standard control.

Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Establish demarcation zones for vehicle and personnel movement considering sensitive vegetation, bird nesting and roosting areas and turtle nesting habitat.	Reduce coastal habitat and fauna disturbance.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control.
Operational restriction of vehicle and personnel movement to limit erosion and compaction.	Reduce coastal habitat erosion and compaction.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control.
Prioritise use of existing roads and tracks.	Reduce coastal habitat and fauna disturbance.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control.
Soil profile assessment prior to earthworks.	Reduce habitat disruption and erosion.	Operational costs associated with soil profile assessment.	**Adopted –** Considered a standard control.
Use of Heritage Advisor if spill response activities overlap with potential areas of cultural significance.	Reduce disturbance to culturally significant sites.	No cost/issue associated with this control measure.	**Adopted –** Considered a standard control to be adopted by the relevant Control Agency.
Pre-cleaning and inspection of equipment (quarantine)	Reduces potential for invasive species to offshore islands	Cost/effort in inspecting equipment	**Adopted –** Considered a standard control.

6.8.4 Environmental Impact Assessment

Receptor	Consequence Level
Light Emissions	

+ Threatened, migratory, and local fauna; + Protected Areas. + Socio-economic receptors	The receptors considered most sensitive to lighting from vessel and shoreline operations are seabirds/shorebirds and marine turtles, particularly over summer months with respect to marine turtles where emerging hatchlings are sensitive to light spill onto beaches. Following restrictions on night-time operations by spill response vessels, which will demobilise to mooring areas offshore with safety lighting only, impacts from vessels are considered to be I- Negligible. The positioning of temporary camps will be done at direction of DoT/ DBCA and following control measures on lighting colour and direction the consequence of shoreline lighting is considered Negligible.
	Fauna (including Threatened/ Migratory/ Local Fauna): I (Negligible) – Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle / introduction of disease. Protected areas: I (Negligible) – No or negligible impact on protected area values. No decline of species population within a protected area. No or negligible alteration, modification, obscuring or diminishing of protected area values. Socio-economic receptors: I (Negligible) – no or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity
Overall worst-case consequence level	I – Negligible
Acoustic Disturbance	
+ Threatened, migratory, and local fauna; + Protected Areas. + Socio-Economic Receptors	The receptor considered most sensitive to vessel noise disturbance are humpback whales during migration season, when they come close to the Montebello Islands and Barrow Island during their peak migration (July-October); and populations of marine turtles, whale sharks and pygmy blue whales. However, following the adoption of control measures to limit close interaction with protected fauna (i.e. Santos Protected Marine Fauna Interaction and Sighting Procedure), a temporary behavioural disturbance is expected only with a consequence of Negligible. With respect to noise from onshore operations (mobile equipment and vehicles), nesting, roosting or feeding birds are considered to be the most sensitive to noise, in particular shorebirds may be aggregating at Muiron Islands, Montebello Islands, Barrow Island and Ningaloo coast. The equipment used is not considered to have excessive sound levels and following direction by DoT and DBCA on the location of temporary camp areas, the consequence to birds from noise is expected to be Negligible. Shorebirds may be official values of the protected area they occur in, and the impact to the protected area from noise is also considered Negligible.
	Fauna (including Threatened/ Migratory/ Local Fauna): I (Negligible) – Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle / introduction of disease. Protected areas: I (Negligible) – No or negligible impact on protected area values. No decline of species population within a protected area. No or negligible alteration, modification, obscuring or diminishing of protected area values.

	Socio-economic receptors: I (Negligible) – no or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity.
Overall worst-case consequence level	I – Negligible
Atmospheric Emissions	
+ Physical environment / habitat: air quality + Threatened, migratory, and local fauna; + Protected areas. + Socio-economic receptors	Atmospheric emissions from spill response equipment will be localised and impacts to even the most sensitive fauna, such as birds, are expected to be Negligible. Because of the localised and low level of emissions, impacts to protected area values, physical environment and socio-economic receptors are predicted to be Negligible. Physical environment/habitat: I (Negligible) – No or negligible reduction in habitat area/function. Fauna (including Threatened/ Migratory/ Local Fauna): I (Negligible) – Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle / introduction of disease. Protected areas: I (Negligible) – No or negligible impact on protected area values. No decline of species population within a protected area. No or negligible alteration, modification, obscuring or diminishing of protected area values. Socio-economic receptors: I (Negligible) – no or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity.
Overall worst-case consequence level	A – Negligible
Operational Discharges and Waste	
+ Threatened, migratory, and local fauna; + Physical environment and habitats; + Protected areas. + Socio-economic receptors	Operational discharges from vessels may create a localised and temporary reduction in marine water quality, which has the potential to impact shallow coastal habitats in particular, however, following the adoption of regulatory requirements for vessel discharges, which prevent discharges close to shorelines, discharges will have a Negligible impact to habitats, fauna or protected area values. Furthermore, washing of vessels and equipment will take place only in defined offshore hot zones preventing impacts to shallow coastal habitats. Because of impacts to fauna, operational discharges from vessels has the potential to impact supported industries such as tourism and commercial fishing however as impacts to fauna are considered negligible any indirect impacts on socio-economic receptors will also be A -negligible. Onshore, the use of flushing water has the potential to damage sensitive shoreline and intertidal habitats, e.g. mangroves, however low pressure flushing only will be used, preventing further damage to habitats or erosion of sediments. For sensitive habitats the deployment of booms will be considered to retain flushed hydrocarbons, if this presents a net benefit. Following these control measures the use of flushing to clean shorelines and intertidal habitats is seen to have a Negligible additional impact to habitats, fauna or protected area values. The cleaning of contaminated vehicles and equipment onshore has the potential to spread oily waste and damage habitats if not contained. Decontamination units will be in used during the spill response thus containing waste and preventing any secondary contamination. The

	consequence of cleaning discharges is therefore ranked as Negligible in terms of impacts to habitats, fauna or protected area values. Sewage, putrescible and municipal waste generated onshore will be stored and disposed of at approved locations. The storage, transport and disposal of hydrocarbon contaminated waste arising from spill response operation actions such as containment and recovery, and shoreline clean up, will be managed by a Santos appointed waste management contractor and dedicated waste containment areas will prevent the spreading or leaching of hydrocarbon contamination.
	Physical environment/habitat: I *(Negligible) – No or negligible reduction in habitat area/function.* Fauna (including Threatened/ Migratory/ Local Fauna): *I (Negligible) – Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle / introduction of disease.* Protected areas: *I (Negligible) – No or negligible impact on protected area values. No decline of species population within a protected area. No or negligible alteration, modification, obscuring or diminishing of protected area values.* Socio-economic receptors*: I (Negligible) – no or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity.*
Overall worst-case consequence level	I – Negligible
Physical Presence and Disturbance	
+ Threatened, migratory, and local fauna; + Physical environment and habitats; + Protected areas.	The use of vessels and nearshore booms has the potential to disturb benthic habitats including sensitive habitats in coastal waters such as corals, seagrass, macroalgae and mangroves. A review of shoreline and shallow water habitats, and bathymetry, and the establishment of demarcated areas for access and anchoring will reduce the level of impact to Negligible. The use and movement of vehicles, equipment and personnel during shoreline response activities has the potential to disturb coastal habitats such as dune vegetation, samphire and mangroves, and important habitats of threatened and migratory fauna including nests of turtles and birds and bird roosting areas. Furthermore, clean-up can involve physical removal of substrates that could cause impact habitats, fauna and alter coastal hydrodynamics. As with vessel use, an assessment of appropriate vehicles and equipment to reduce habitat damage, along with the establishment of access routes/demarcation zones, and operational restrictions on equipment/vehicles use will limit sensitive habitat damage and damage to important fauna areas. The establishment of temporary camp areas will be done under direction of DoT and DBCA with suitable advice sought if access is needed to culturally significant areas. Following these and other control measures the resultant consequence to the physical environment and habitat is assessed as Minor, indicating that there may be a detectable reduction in habitat area from response activities (as separate from spill impacts), but recovery will be relatively rapid once spill response activities cease. As with all spill response activities this disturbance will only occur if there is a net benefit to accessing and cleaning shoreline areas. The main direct disturbance to fauna would be the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling impacts, such as birds and marine turtles. This would only be done if this intervention were to deliver a net benefit to the species but may result in a Minor

	consequence following compliance with the WA Oiled Wildlife Response Plan and the Pilbara Region Oiled Wildlife Response Plan. These habitats/environments are likely to be values of the protected area they occur in, and the impact to the protected area from physical disturbance is also considered Minor. The disturbance to marine and coastal natural habitat, as well as the potential for disruption to culturally sensitive areas, which may occur in specially protected areas, may have flow on impacts to socio-economic values and industry (e.g. tourism, fisheries). This impact is considered Minor (II).
	Fauna (including Threatened/ Migratory Fauna): II (Minor) – Detectable but insignificant decrease in local population size. Insignificant reduction in area of occupancy of species. Insignificant loss/disruption of habitat critical to survival of a species. Insignificant disruption to the breeding cycle of local population Physical environment/habitat: II (Minor) – Detectable but localised and insignificant loss of area/function of habitat. Rapid recovery evident within approximately 1 year (seasonal recovery). Protected Areas: II (Minor) – Detectable but insignificant impact to on one or more of protected areas values. Socio-economic receptors: II (Minor) – Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.
Overall worst-case consequence level	II – Minor
Chemical Dispersant Application	
+ Threatened, migratory, and local fauna; + Physical environment and habitats; + Protected areas; + Socio-economic receptors.	The use of chemical dispersants has the potential to increase the distribution and concentration of entrained hydrocarbon and dissolved aromatic hydrocarbons within the water column. Entrained hydrocarbon and dissolved aromatic hydrocarbons are expected to be elevated adjacent to the release site with the potential for increased impacts to benthic and pelagic fishes, sharks and invertebrates. Modelling of dispersant application on (Intertek, 2019e) indicated that the effect of increased entrained hydrocarbon and dissolved aromatic hydrocarbon concentration. The generic impacts to receptors from entrained hydrocarbon and dissolved aromatic hydrocarbons described in **Section 7.5** are considered to apply. The above consequence rankings assume the controls outlined for dispersant operations in the OPEP have been implemented, that is the dispersants are of low risk to the environment and are tested as effective on the released hydrocarbon, and a NEBA process has been applied using up to date spill modelling and operational monitoring results such that the process is confirmed as having a net environmental benefit. The above assessment has considered only the potential negative effects of dispersants on marine fauna and habitats from entrained hydrocarbon and dissolved aromatic hydrocarbons. Dispersant application would lead to a reduction in the spatial extent of surface oil above 10 g/m^2, a reduction in the maximum concentration of surface oil arriving at shorelines, and a reduction in the volume of oil stranded on shorelines. These widespread positive effects to shoreline habitats and marine and coastal fauna are considered to outweigh the potential localised negative impacts outlined above. Thus from an overall environment perspective, the dispersant strategy is predicted to have a net benefit based on the available evidence, noting that this would be

	confirmed or otherwise prior to and during any dispersant operations by a NEBA using situational data.
	Threatened/ Migratory/ Local Fauna: II (Minor) - *Detectable but insignificant decrease in local population size. Insignificant reduction in area of occupancy of species. Insignificant loss/disruption of habitat critical to survival of a species. Insignificant disruption to the breeding cycle of local population.* Physical environment/habitat: II (Minor) - *Detectable but localised and insignificant loss of area/function of habitat. Rapid recovery evident within ~ 1 year (seasonal recovery).* Protected Areas: II (Minor) – *Detectable but insignificant impact to on one or more of protected areas values.* Socio-economic receptors: II (Minor) - *Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.*
Overall worst-case consequence level	II – Minor
Disruption to Other Users of Marine and Coastal Areas and Townships	
+ Socio-economic receptors.	The use of vessels in the nearshore and offshore environment and spill response activities at shoreline locations, and within townships, may exclude general public and industry use. It should be noted that this is distinct from the socio-economic impact of a spill itself which would have a far greater detrimental impact to industry and recreation. Following the application of control measures it is considered that the additional impact of spill response activities on affected industries would be *Minor*.
	Socio-economic receptors: *II (Minor) - Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.*
Overall worst-case consequence level	I – Minor

6.8.5 Demonstration of ALARP

A NEBA is the primary tool used during spill response to evaluate response strategies with the goal of selecting strategies that result in the least net impact to key environmental sensitivities. The NEBA process conducted as a spill occurs, will identify and compare net environmental benefits of alternative spill response options. The NEBA will effectively determine whether an environmental benefit will be achieved through implementing a response strategy compared to undertaking no response. NEBA will be undertaken by the relevant Control Agency for the activity. For those activities under the control of Santos, the Incident Management Team (IMT) Environmental Team Leader will be responsible for reviewing the priority receptors and selected response strategies identified within this EP and coordinating the NEBA for each operational period. This will ensure that at the strategy level, the response operations reduce additional environmental impacts to ALARP.

Spill response activities will be conducted in offshore and coastal waters using vessels and aircraft. The greatest potential for additional impacts from implementing spill response is considered to be to wildlife in offshore waters from oiled wildlife response activities, and to shoreline habitats and fauna receptors within shallow waters or on shorelines from shoreline clean-up activities.

Given the types of activities considered appropriate to responding to a worse-case spill and the scale of operations, standard control measures adopted by Santos for spill response to reduce the level of additional impacts are considered to reduce these impacts to ALARP. This includes working with the relevant Control Agency for spill response and applying the process and standards e.g. for oiled wildlife response as included within the WA Oiled Wildlife Response Plan.

Santos have considered the actions prescribed in the Recovery Plan for Marine Turtles in Australia (DoEE, 2017) and Approved Conservation Advice for other relevant threatened fauna relevant to spill responses for the activities to minimise noise and light impacts on marine cetaceans, fish, sharks and marine turtles, especially flatback turtles. The proposed activity will not result in significant impacts on these species and implementation of identified control measures is in line with the relevant Conservation Advice and Recovery Plans. Pollution events (such as hydrocarbon spills) could impact on fauna, and the use of vessels and equipment during the spill response could result in potential impacts as described within this EP. Control measures in place for vessel and helicopter use will reduce potential impacts to marine fauna and these are consistent with current conservation advice. The assessed residual consequence for this impact is minor and cannot be reduced further without grossly disproportionate costs. It is considered therefore that the impact of the activities conducted is ALARP.

6.8.6 Acceptability Evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence is a II (Minor).
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian Marine Park zoning objectives)?	Yes – IUCN principles of nearby reserves met (**Section 3.2.3**). Control measures implemented will minimise the potential impacts from spill response activities protected areas and their values, and to species identified in Recovery Plans and conservation advice as having the potential to be impacted. Consistent with relevant species recovery plans, conservation management plans and management actions set out in **Table 3-8**
Are performance standards consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this event. During any spill response, a close working relationship with relevant regulatory bodies (e.g. DoT, DBCA, AMSA, Director of National Parks) will occur and thus there will be ongoing consultation with relevant stakeholders on the acceptability of response operations. Wildlife response will be conducted in accordance with the WA Oiled Wildlife Response Plan (WA OWRP).
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The implementation of response activities to reduce the potential impacts from a spill are required by legislation. The spill response options selected have been demonstrated to show a net environmental benefit, are standard industry practice and consistent with relevant standards and guidelines, including the NatPlan. No concerns from stakeholders have been raised regarding response activities and the controls proposed reduce the consequences of the potential impacts to minor and ALARP. The controls used during spill response activities are therefore considered to reduce additional impacts and risks to an acceptable level.

7 Environmental Assessment for Unplanned Events

OPGGS(E)R 2009 Requirements
Regulation 13(5)
The environment plan must include: a) details of the environmental impacts and risks for the activity; b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and c) details of the control measures that will be used to reduce the impacts and risks of the activity to as low as reasonably practicable and an acceptable level.
Regulation 13(6)
To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.
Regulation (13)(7)
The environment plan must: a) set environmental performance standards for the control measures identified under paragraph (5)(c); b) set out the EPOs against which the performance of the titleholder in protecting the environment is to be measured; and c) include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

The environmental assessment identified eight potential sources of environmental risks associated with the unplanned events for this activity. The results of the environmental assessment are summarised in **Table 7-1**.

Section Reference	Unplanned event	Residual Risk Level
7.1	Introduction of Invasive Marine Species	Medium
7.2	Marine Fauna Interactions	Low
7.3	Release of Solid Objects	Low
7.4	Release of Materials Hazardous to the Marine Environment (solids and liquids)	Low
7.6	Subsea Release of Hydrocarbon from a Production Well to the Marine Environment	Low
7.7	Subsea Release of Hydrocarbon from the Subsea System to the Marine Environment	Low
7.8	Surface Release of Hydrocarbon to the Marine Environment	Low
7.9	Surface Release of Marine Diesel to the Marine Environment	Very Low
7.10	Surface Release of Heavy Fuel Oil to the Marine Environment	Very Low
7.11	Subsea Release of Dry Gas to the Marine Environment	Low

A comprehensive risk and impact assessment for each of the unplanned events, and subsequent control measures proposed by Santos to reduce the risk and impacts to ALARP, are detailed in the following sub-sections.

Table 7-1: Summary of the Residual Risk Associated with Unplanned Events

Section Reference	Unplanned event	Residual Risk Level
7.1	Introduction of Invasive Marine Species	Medium
7.2	Marine Fauna Interactions	Low
7.3	Release of Solid Objects	Low
7.4	Release of Materials Hazardous to the Marine Environment (solids and liquids)	Low
7.6	Subsea Release of Hydrocarbon from a Production Well to the Marine Environment	Low
7.7	Subsea Release of Hydrocarbon from the Subsea System to the Marine Environment	Low
7.8	Surface Release of Hydrocarbon to the Marine Environment	Low
7.9	Surface Release of Marine Diesel to the Marine Environment	Very Low
7.10	Surface Release of Heavy Fuel Oil to the Marine Environment	Very Low
7.11	Subsea Release of Dry Gas to the Marine Environment	Low

7.1 Introduction of Invasive Marine Species

7.1.1 Description of Event

Event	Invasive Marine Species (IMS) could potentially be introduced to the operational area from the FPSO or vessels through ineffective ballast water management or through ineffective biofouling management. Potential sources for the transfer and establishment of IMS may include: + Biofouling on support vessels and external or internal (e.g., sea chests, seawater systems) niches; + Biofouling on vessels and other external niches (e.g. propulsion units, steering gear and thruster tunnels); + Biofouling of vessels or other internal niches (e.g. sea chests, strainers, seawater pipe work, anchor cable lockers and bilge spaces); + Biofouling on equipment that routinely becomes immersed in water (e.g. ROV, AUV); + Ballast water exchange; and + Cross contamination between vessels and the FPSO. The FPSO is routinely serviced by support vessels. Other activities requiring vessel use, such as IMMR are less frequent. Biofouling organisms may attach to the vessel hull, particularly in areas such as seams and unpainted surfaces which are easy to attach to or where water turbulence

	is lowest (e.g. niches, sea chests etc.). Organisms can also be drawn into ballast tanks during cargo unloading as additional water is required for stabilisation. Some in-water maintenance / inspection work may require localised marine growth (sessile invertebrates and algae) removal to access critical ship or production operating systems. The areas affected will be small (e.g. around hull apertures and welds, areas of the propeller/thruster, DTM buoy, chains, moorings risers or around fitted cathodic protection devices) and the activities will not be required on a frequent basis.
Extent	**Localised**: The potential exists for marine pest species to be introduced to the operational area. For the FPSO it is unlikely that any introduced marine pest species would survive and spread outside the operational area given the seabed substrate (bare sand), limited light availability and reduced ambient temperature at the seabed (>300 m).
Duration	**Permanent**: Event may occur during the duration of field life. Temporary to long-term impact on the marine environment (in the event of successful translocation and establishment).

7.1.2 Nature and Scale of Environmental Impacts

Potential Receptors: Marine ecosystem as a whole and commercial/recreational users of the marine environment

IMS are marine plants, animals and algae that have been introduced into a region that is beyond their natural range but could survive, and possibly thrive (DAWR, 2017). The majority of climatically compatible IMS to the NWS are found in south-east Asian countries. IMS generally have characteristics that make them superior (in survival) and give them the ability to outcompete native species for food, space or light to the point that the native species is lost.

Some IMS pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports and tourism (DAWR, 2017). When IMS achieve pest status, they are commonly referred to as introduced marine pests and can cause a variety of adverse effects in a receiving environment, including:

+ Over-predation of native flora and fauna;
+ Out-competing of native flora and fauna for food;
+ Human illness through released toxins;
+ Depletion of viable fishing areas and aquaculture stock;
+ Reduction of coastal aesthetics; and
+ Damage to marine and industrial equipment and infrastructure.

Species of concern are those that are not native to the region; are likely to survive and establish in the region; and are able to spread by human mediated or natural means. Species of concern vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities.

It is recognised that artificial, disturbed and/or polluted habitats in tropical regions are susceptible to introductions, which is why ports are often areas of higher IMS risk (Neil *et al*., 2005). However, in Australia there are limited records of detrimental impact from IMS compared to other tropical regions (such as the Caribbean).

Following their establishment, eradication of IMS populations is difficult, limiting management options to ongoing control or impact minimisation. However, this is dependent on the environmental conditions and species. For this reason, increased management requirements have been implemented in recent years by Commonwealth and State regulatory agencies.

Potential sources for the introduction of IMS into the operational area include biofouling on the vessels, including external niches (e.g. propulsion units, steering gear and thruster tunnels) and internal niches (e.g. sea chests, strainers, seawater pipe work, anchor cable lockers and bilge spaces).

Equipment that is submerged in water for periods of time (e.g. ROVs and AUVs) may acquire IMS, which can be spread if the equipment is not cleaned to low risk prior to use in pest free areas.

Vessels based in local ports do not carry the same quarantine risks as international vessels or out of State vessels as they supply the same waters as those the operational area resides in. Given the depths in the operational area (>300 m) establishment of IMS is unlikely to occur on the seabed due to the lack of light or suitable habitat to sustain growth or survival, there is potential for IMS to establish on the FPSO. Interactions, between the FPSO and vessels (likely Australian sourced) will be limited. Time spent by vessels near the FPSO is typically limited to vessel transfers and support activities.

Within the operational area, soft sediment is the dominant habitat. A survey of seabed habitat has previously been conducted at the Coniston/Novara fields (RPS, 2011a) and at the Van Gogh Field (Apache, 2009). The seabed survey at the Coniston/Novara fields, along the flowlines and production manifold locations, has revealed a flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (including anemones, sea stars, soft corals, crabs, shrimp and sea urchins) and an infaunal community dominated by polychaetes and crustaceans. This survey found no unique communities or communities of particular regional significance (RPS, 2011a). Similarly, a seabed survey at the Van Gogh field has revealed a flat substrate comprising mud and silts sediments with sparse epifauna (including sponges, echinoderms and crustaceans) and an infaunal community comprising mainly polychaetes and crustaceans (Apache, 2009). Given the featureless nature of the seabed and the lack of any hard substrates for the IMS to attach to the risk of IMS establishment is unlikely.

The removal of a fouling community in localised areas on the FPSO is not predicted to have any measurable impact on an endemic populations or local ecosystem level as fouling communities are expected be of regional origin as has been demonstrated in a previous in-water biofouling survey of the FPSO hull which identified fouling communities “specifically from the Dampier area or from northern Australia more generally” (RPS, 2011b).

Transfer of IMS between vessels is considered very unlikely given ballast water and biofouling controls which will be implemented and the limited opportunities for transfer of IMS between vessels and the FPSO.

7.1.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No introduction of invasive marine species [EPO-NV-08].

The control measures considered for this event are shown in **Table 7-2**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-2: Control Measures Evaluation for Introduction of Invasive Marine Species

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-51	Invasive Marine Species Management Plan	The risk of introducing IMS are reduced due to assessment prior to contracting vessel and temporary in-water equipment.	Personnel costs involved in risk assessing vessels in accordance with the IMSMP. Costs associating with reducing the vessel risk to 'low' e.g. dry docking, hull cleaning or additional costs due to inspections. Could lead to potential delays and therefore costs, in vessel contracting process due to availability of vessels.	**Adopted** – minimal personnel costs and potential delays or costs to project are considered outweighed by the benefits of reducing the risk of IMS.
NV-CM-52	Anti-foulant system	The risk of introducing IMS are reduced due to anti-foulant systems.	Could lead to potential delays and therefore costs, in vessel contracting process due to availability of vessels with appropriate anti-foulant systems.	**Adopted** – minimal potential delays or costs to project are considered outweighed by the benefits of reducing the risk of IMS.
NV-CM-53	Ballast water management	Reduces the risk of introducing IMS through managing ballast water exchange and identifying high risk ballast water.	Personnel costs in producing and implementing ballast water management and in maintaining record books and logs.	**Adopted** – minimal personnel costs are considered outweighed by the benefits of reducing the risk of IMS and is a legislated requirement.
Additional Control Measures				
N/A	Zero discharge of ballast water	Would reduce the potential for IMS by implementation of no ballast water exchange polity on vessels.	Ballast water exchange required on the vessels for stability.	**Rejected** – On the basis that ballast water exchange is a safety-critical activity for marine operations.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
N/A	Reduction in frequency of vessel use	Would reduce total amount of potential IMS contact.	May result in larger transfers of chemicals and required supplies, larger vessel requirement.	**Rejected** – though frequency lowers potential consequence is increased for an unplanned spill event.
N/A	Pre-mobilisation chemical dosage of ballast water to eliminate IMS	Would reduce potential for IMS to establish by eliminating individuals present in ballast water.	High cost compared to existing risk; introduction of additional chemicals to the marine environment which would likely be toxic to native marine species.	**Rejected** – Based on increased risk to marine environment and high cost considered disproportionate compared to base case risk.
N/A	Heat treatment of ballast water to eliminate IMS	Would reduce potential for IMS to establish by eliminating individuals present in ballast water.	High cost compared to existing risk; introduction of water at much higher temperature than surrounding marine environment would likely result in death of native marine species.	**Rejected** – Based on increased risk to marine environment and safety compared to base case risk.
N/A	Utilise an alternative ballast system to avoid uptake/discharge of water	Eliminate need for ballast water exchange therefore decreasing risk of introducing IMS through ballast water.	Vessels suitable for the activity may not have options for alternative ballast system therefore would require modification at significant cost.	**Rejected** – Costs disproportionately high compared to environment benefit.
N/A	Contract vessels only operating in local, State or National waters to reduce potential for IMS	Potential for IMS to be transported into area is reduced but not eliminated by not utilising vessels that have originated from areas of higher IMS risk.	Often contracted vessels are sourced based on proximity and availability and frequently are from local, State or National waters. Vessels and equipment suitable for the activity may not be available in Local/State/National waters. Potential significant costs and delay in activity	**Rejected** – Complete restriction on contracting not feasible.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			schedules by only contracting Local/State/National vessels.	
N/A	Mandatory dry-docking of vessels prior to entering operational area to inspect or clean vessel and/or equipment and remove biofouling	Minimise risk of IMS on vessel or associated equipment.	Significant cost for this to occur and would lead to scheduling delays. Potential OHS risks associated with in-water inspection and cleaning.	**Rejected** – Costs disproportionately high compared to environmental benefit given other controls in place already reduce the risk.
N/A	Removal of a fouling community in localised areas on the FPSO at dry-dock rather than in-water	Remove requirement for removal of fouling within the operational area.	Is not considered practicable given the disruption to operations and costs involved.	**Rejected** – Costs disproportionately high compared to environmental benefit given other controls in place already reduce the risk.

7.1.4 Environmental Impact Assessment

Description – Invasive Marine Species	
Receptors	Threatened, migratory, and local fauna; Physical environment and habitats; Socio-economic receptors.
Consequence	IV – Major

<u>Threatened, Migratory, and Local Fauna</u>

Ballast water is responsible for 20–30% of all marine pest incursions into Australian waters, however, research indicates that biofouling (the accumulation of aquatic micro-organisms, algae, plants and animals on vessel hulls and submerged surfaces) has been responsible for more foreign marine introductions than ballast water. IMS, if they successfully establish, can out-compete native species for food or space, preying on native species or changing the nature of the environment and can subsequently impact on fisheries or aquaculture.

<u>Physical Environment and Habitats;</u>

If an IMS is introduced, they have been known to colonise areas outside of the areas they are introduced to. In the event that an IMS is introduced into the operational area, given the lack of diversity and extensiveness of similar benthic habitat in the region, there would only be a minor reduction in the physical environment should it be established in the operational area. No threatened ecological communities are present in the operational area that could be affected.

<u>Socio-economic Receptors.</u>

Description – Invasive Marine Species	
Changes to the can subsequently impact on fisheries or aquaculture. Given the impacts above and the ability for IMS to spread further afield once established the overall consequence level was assessed as **Major.**	
Likelihood	C- Possible
The pathways for IMS introduction are well known, and subsequently standard preventative measures are proposed. The ability for IMS to colonise a habitat is dependent on a number of environmental conditions. It has been found that highly disturbed environments (such as marinas) are more susceptible to colonisation than open water environments where the number of dilutions and the degree of dispersal are high (Paulay *et al.*, 2002). Given the depth of the operational area (>300 m) it presents an unfavourable habitat for colonisation (i.e. light limiting and low habitat biodiversity with sparse epibiota), IMS would have to survive translocation and subsequently establish and colonise on at lower water depths. IMS translocation and establishment is understood to have occurred previously through the use of industry vessels. With control measures in place to reduce the risk of introduction of IMS, the likelihood of introducing an IMS is considered *Possible.*	
Residual Risk	The residual risk associated with this event is **Medium**

7.1.5 Demonstration of ALARP

Vessel presence is required to carry out NV Operations. The entry of international vessels into Australian waters is permissible under the Commonwealth Biosecurity Act 2015. However, vessels for the NV Operations are typically soured from local ports.

The *Invasive Marine Species Management Plan (IMSMP) (EA-00-RI-10172*) is consistent with the Biosecurity Act 2015 and National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018). The IMSMP provides guidance on assessing the risk for vessels translocating marine pest species and utilises the risk assessment, to assess the risk of marine pests entering operational areas from contracted vessel from out of State waters. Generally, vessels are sourced from local waters although out of State vessels may be used provided, they are assessed as ‘low risk’ in accordance with the IMSMP. The biofouling risk assessment approach adopted by Santos will ensure that the Aquatic Resources Management Act 2016[6] and associated regulations prohibiting the introduction of non-endemic fish species will be met

Ballast water exchange will be managed through Ballast Water Management actions consistent with the Australian Ballast Water Management Requirements (Department of Agriculture and Water Resources), and a vessel biosecurity risk assessment in accordance with the Invasive Marine Species Management Plan (EA-00-RI-10172) will be undertaken to demonstrate that vessels are low risk so that IMS are not introduced. Smaller vessels are more likely to be sourced locally, reducing the potential for IMS presence. Therefore, the frequency of vessels required in the field is considered ALARP, based on the required safe operation and maintenance requirements of the facility.

In-water cleaning of the localised areas of the FPSO, and subsea infrastructure within the operational area will be performed only as required for inspection and maintenance purposes (e.g. as required for maintaining class). Localised and infrequent cleaning of marine growth may be required to facilitate this inspection. Removing this requirement could jeopardise the safe operation of the FPSO. The in-water cleaning of localised areas of the FPSO for class certification is considered acceptable following adoption of the requirements within the *IMSMP*.

[6] The Aquatic Resources Management Act 2016 will replace the Fish Resources Management Act 1994 and the Pearling Act 1990. The new act was scheduled for commencement on 1 January 2019; however, commencement has been deferred while an amendment to the act is progressed.

During the NV Operations, given the adoption of the industry standard management controls listed above it is considered that all practicable measures have been implemented to ensure the likelihood of introduction of IMS have been reduced to ALARP.

7.1.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Introduction of invasive marine species residual risk ranking is Medium
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – management consistent with: + Biosecurity Act 2015 and National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018). + Fish Resources Management Act 1994 (expected to be replaced by the Aquatic Resources Management Act 2016 in 2019). + Performance standards are consistent with the Australian Department of Agriculture and Water (DAWR) Australian Ballast Water Requirements–Version 7 (2017) Activity in accordance with EPBC approval conditions (EPBC 2007/3213). Condition 1 requires ballast water management for international vessels arriving in Australia.
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes –CCG raised matters relating to dry docking (Section 4.4). Control measures and associated environment performance standards are included (**Section 7.1.3** and **Table 8-2**) to address stakeholder concerns
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

IMS risk associated with vessel and equipment use and FPSO presence is well understood and subject to regulation. Vessels and in-sea equipment that are internationally mobilised will meet Australian biosecurity requirements and management is consistent with Biosecurity Act 2015 and Fish Resources Management Regulations 1995 and the National Biofouling Guidance for the petroleum industry.

Ballast water is managed in accordance with the DAWR Australian Ballast Water Requirements–Version 7 (2017). The risk from introduction of marine pests from ballast water exchange from the FPSO is acceptable through implementing the controls within its Biofouling Management Plan and the requirements to obtain ‘low risk’ status before returning to the operational area.

It should be noted that the offshore location and water depths (>340 m) in the operational area reduces the probability of successful establishment in the event of introduction.

No stakeholder concerns have been raised regarding this unplanned event and the proposed controls will reduce the residual level of risk to low and ALARP. Therefore, the medium level of residual risk associated with IMS is considered to be environmentally acceptable.

7.2 Marine Fauna Interactions

7.2.1 Description of Event

Event	The physical presence of the vessels and helicopters and within the operational area results in the potential for marine fauna interactions. There is the potential for support or project vessels to strike marine fauna including cetaceans, fish and sharks, marine reptiles and seabirds. The main collision risk associated with the activity is through vessel collision with large, slow moving cetaceans. Fauna interaction may also occur from helicopter collision, during take-off and landing. As described in **Section 2.4.1.1**, the FPSO may disconnect and reconnect to the DTM buoy for cyclone avoidance, to leave the field for maintenance activities (e.g. shipyard campaigns) or in the event of cessation of operations (**Section 2.16**). To allow for the pick-up and reconnection of the DTM when the FPSO has an intention to return, a floating pickup line arrangement is left attached to the DTM. Under a steady current stream when the FPSO is disconnected, this pick-up line arrangement can extend to approximately 500m in length (made up of three lengths of cow hitched floating marine line/DTM lifting line) and poses a potential risk to marine fauna through entanglement.
Extent	**Localised**: Within the operational area, in the immediate vicinity of vessels or helicopters, while moving.
Duration	**Permanent**: Event could occur during field life. Support vessel presence is approximately once every two weeks. Project vessels are required less frequently, as per operational requirements.

7.2.2 Nature and Scale of Environmental Impacts

<u>Potential receptors: Fish and sharks, cetaceans, marine reptiles and sea birds.</u>

Impacts of marine interactions with fish and sharks, cetaceans, marine reptiles and sea birds from the physical present of vessels and helicopters within the operational area are outlined below.

7.2.2.1 Vessels

Movement of vessels in the operational area introduces the potential for interaction with marine fauna present at the same location during the NV Operations. Marine fauna in surface waters that would be most at risk from vessel collision include marine mammals, marine turtles and whale sharks other faster moving species are likely to avoid or not be impacted by the presence of vessels.

Interactions between vessels and marine fauna are occurring more frequently, especially on continental shelves where high vessel traffic and cetacean habitat occurs (WDCS, 2006). There have been recorded instances of cetacean deaths in Australian waters (e.g. a Bryde’s whale in Bass Strait in 1992) (WDCS, 2006), though the data indicates this is more likely to be associated with container ships and fast ferries.

Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) indicates that humpback whales are one of the most frequently reported whale species involved in vessel strikes worldwide (Laist *et al*., 2001; Jensen & Silber, 2003). This observation is supported by Australian studies referenced in The Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (2018). Similarly, boat strike is recognised by the Approved Conservation Advice for *Rhincodon typus* (whale shark) as one of the threats to their recovery.

The most commonly sighted whale in continental shelf waters of the region is the humpback whale. A BIA for humpback whale migration also overlaps the operational area. During the humpback migration period, there is the potential for humpback whales to be encountered in the operational area. Blue, sei, fin, sperm whale and southern right whales may also transit through the operational area and a pygmy blue whale BIA for distribution overlaps the operational area, although it is unlikely that there will be significant numbers of these species encountered, there is still the potential for interaction with all these species.

The reaction of whales to the approach of a vessel is variable. Some species remain motionless when in the vicinity of a vessel while others are known to be curious and often approach vessels that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving vessels (Richardson et al., 1995).

The flatback turtle is one of five marine turtles which could occur within the operational area (loggerhead, green, leatherback, hawksbill, flatback turtles). The operational area is 7 km from a internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. It is possible that individual turtles may be encountered during NV Operations, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected. There is a risk of potential vessel strike between moving vessels and turtles.

Turtle/vessel interactions arising from increased vessel traffic is recognised as one of several key impacts to marine turtles in the Recovery Plan for Marine Turtles 2017–2027 (DoEE, 2017). Marine turtles are highly mobile and given low speeds of vessels used for operations are likely to be able to move from an area where there is vessel activity. However, given the distance to nesting beaches (operational area is located 35 km from the Ningaloo coast and 40 km from the Muiron Islands) and the absence of important foraging habitat for any species in the operational area, large numbers of turtle encounters are not expected.

Dugong are known to occur in and around seagrass growth areas and to exhibit some stereotypical inquisitive behaviours (Anderson, 1982). Though they are migratory, some species habitat is likely to occur within the wider region. The risk of dugong strike can be lowered significantly by minimising movements directly over seagrass beds in shallow waters. Seagrasses are unlikely to be present within the operational area, given the water depths and insufficient light availability.

Boat strike is recognised by the Approved Conservation Advice for *Rhincodon typus* (whale shark) (TSSC, 2015b) as one of the threats to their recovery. The operational area does not lie within a foraging BIA for whale shark and given the offshore location large numbers of species are not anticipated. It is however possible that individuals may transit through the operational area, therefore the potential exists for marine fauna interaction.

7.2.2.2 Helicopters

Several protected species of marine birds have potential habitats or migratory routes in and around the operational area (**Section 3.2.4**). Risk to birds is increased during landing and take-off. It is also expected that helicopter noise will elicit a behavioural response in birds to avoid collision and that the relatively low speeds that helicopters are flying at during take-off and landing the frequency of helicopter strike is very rare.

Helicopter flights to the FPSO occur during daylight only. The operational area is located 35 km from the Ningaloo coast and 40 km from the Muiron Islands, distant from any bird roosting sites, potential interactions and subsequent physiological impacts to birds from helicopter strikes is considered unlikely.

Although unlikely to occur, birds striking a helicopter may cause injury or mortality of an individual, which would cause a minor disruption to a small proportion of the population with no significant impact to overall population viability.

7.2.2.3 DTM pickup line arrangement

Marine fauna may become entangled within the DTM pickup when the FPSO is off station. Species more likely to be at risk of entanglement are larger marine fauna (e.g. whales, turtles). Allowing for the pickup line to 'stream' reduces the potential for the rope to become entangled on itself creating a 'bird-nest' like structure. It is considered that a tangled rope on the sea surface is a higher risk of whale entanglement compared to a single streaming strand.

A birds-nest within the rope arrangement is also considered to create a higher risk to prop/vessel snagging compared to a single length of floating line.

7.2.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No injury or mortality to EPBC Act 1999 and WA Biodiversity Conservation Act 2016 listed fauna during operational activities [EPO-NV-01].

The control measures considered for this event are shown in **Table 7-3**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-3: Control Measures Evaluation for Marine Fauna Interaction

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-01	Procedure for interacting with marine fauna	Reduces risk of physical and behavioural impacts to EPBC listed marine fauna from interactions with vessels and helicopters.	Potential delay in vessel movement increasing activity duration and costs to Santos. Personnel costs involved in reporting sightings to authorities.	**Adopted** – Benefits in reducing risk of impacts to marine fauna outweigh the costs. Implementing relevant EPBC procedures for interacting with EPBC listed marine fauna complies with the EPBC Regulations.
NV-CM-22	DTM buoy attachment line management when FPSO off station for: + longer term absences	Limiting the length of attachment/pick up line from the DTM when the FPSO is off location for	Organisational costs associated with vessel to limit the length of the pickup line arrangement from the DTM buoy	**Adopted** – Benefits considered to outweigh negligible costs to Santos

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
	such as shipyard campaigns, or + if the FPSO is permanently off location.	extended periods of time, reduces the risk of interference with other vessels (not withstanding they should not be within the 500m safety exclusion zone around the DTM buoy) and also reduces potential for entanglement with marine fauna.		
NV-CM-23	Add a float/buoy to the DTM pick-up line arrangement when FPSO off location for longer term absences (i.e. shipyard campaigns).	With a float/buoy attached, the rope arrangement streams in direction of the prevailing current/wind conditions. This streaming effect reduces the potential for the rope to become entangled on itself creating a 'bird-nest' like structure. It is considered that a tangled rope on the sea surface is a higher risk of whale entanglement compared to a single strand. A birds-nest within the rope arrangement is also considered	Organisational and logistics costs associated with enabling the support vessel to attach the float/buoy to the pickup line arrangement.	**Adopted** – Benefits considered to outweigh negligible costs to Santos

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		to create a higher risk to prop/vessel snagging compared to a single length of floating line. Although not intended to be a navigational hazard marker, it will also provide a visual cue to other marine users who inadvertently enter the 500m PSZ.		
NV-CM-54	Visual inspection: Use shared services vessels with neighbouring oil and gas operators when FPSO is off station for longer absences (e.g. shipyard campaign).	Should a whale become entangled, frequent visual inspections would result in early detection and the opportunity to free the whale.	Additional cost associated with adding a visual inspection task to shared services vessel with neighbouring oil and gas operators Frequency of inspections would be approximately once every two weeks, being dependent on suitable weather conditions and operational priorities and constraints. Timing and frequency of visits would not be under Santos control. This control does not alter the likelihood of entanglement.	**Adopt** - The ability to obtain visual checks on the status of the pick-up line arrangement with float attached whilst the NV is off station outweighs the issues of not being able to control frequency and timing of visits when using shared services vessels.
NV-CM-55	Visual inspection: dedicated vessel based monitoring to supplement frequency of shared services vessels to inspect DTM pick up line	Should a whale become entangled, frequent visual inspections would result in early detection and the	Additional cost associated with mobilising a vessel dedicated to this task. Use vessels that already have Master	**Adopt** - Cost associated with inspections to maintain a frequency of 4 times per month (weather

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
	arrangement when FPSO is off station for longer absences (e.g. shipyard campaign).	opportunity to free the whale	Services Agreement with Santos. Local Service Providers Used to supplement the shared vessel inspections and also subject to suitable weather conditions. This control does not alter the likelihood of entanglement.	dependent) is considered ALARP.
Additional Control Measures				
N/A	Adopt further measures to those outlined in 'EPBC Regulations 2000 — Part 8 Division 8.1' during peak periods of ecological sensitivity, e.g. additional management considerations for vessels outlined in the Australian National Guidelines for Whale and Dolphin Watching (2017)	Potentially provide an additional level of protection of marina fauna.	Administrative costs to update existing procedure. Operational costs through interruption to activities through implementation of controls developed for an industry trying to get close to marine fauna, when Santos activities aim to avoid fauna.	**Rejected** - The existing control “procedure for interacting with marine fauna” has been written in accordance with the EPBC Act and other relevant guidelines. A review of this procedure against the Australian National Guidelines for Whale and Dolphin watching found that there are no additional relevant controls in the Australian National Guidelines for Whale and Dolphin watching and therefore adopting this control is not ALARP.
N/A	Dedicated Marine Fauna Observer (MFO) on vessels	Improves ability to spot and identify marine fauna at risk of collision.	Additional cost of contracting several specialist MFO.	**Rejected –** Cost disproportionate to increase in environmental benefit given existing low level of risk.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
N/A	Undertake activities only during daylight hours	Reduced potential for a vessel-fauna collision occurring as activities only undertaken during daylight hours when visibility highest.	Lengthens duration of the activity as operations only continue for approximately 10 hours/day. Increase cost due to increased activity time (more than double the cost). Lengthened schedule results in increased impacts and risks (e.g. planned emissions and discharges, interference with other marine users, etc.).	**Rejected –** Substantial additional cost due to doubling of activity duration. No overall environmental benefit as results in increased impacts and risks.
N/A	Reduce frequency and size of vessels	May reduce the risk from vessels. Impacts are expected to be negligible as the number of vessel activities required are minimal.	Elimination of vessels from the field would not achieve the Santos legal requirements for petroleum production, or work-plan objectives for oil and gas production and may compromise safety standards to other marine users.	**Rejected** – Cost disproportionate to increase in environmental benefit.
N/A	Restrict vessels and helicopters movements during periods when sensitive marine fauna is present	Reduce risk of collisions (causing harm) during environmentally sensitive periods for listed marine fauna.	Limiting vessels from the field would not achieve the Santos legal requirements for petroleum production, or work-plan objectives for oil and gas production and may compromise safety standards to other marine users.	**Rejected** – Cost disproportionate to increase in environmental benefit.
N/A	Eliminate vessel/helicopter movements	Would reduce total amount of potential fauna contact.	May result in larger transfers of chemicals and required supplies, larger vessel requirement. Elimination is not possible.	**Rejected** – though frequency lowers potential consequence is increased not possible to maintain NV Operations without

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				use of vessels/helicopters.
NA	Limiting the length of pick up line arrangement when the FPSO is leaving the field for cyclone avoidance	The length of floating rope on sea surface is reduced resulting in reduction of the hazard associated with whale entanglement and interference with other marine users.	Costs and safety issues associated with having a support vessel to limit the pickup line arrangement length, whilst trying to assist the FPSO to safely get off location, as well as avoid impending cyclone itself.	**Rejected** Costs and safety issues outweigh the environmental benefit to be gained It is a safety critical requirement that the FPSO and support vessel can leave the field quickly, efficiently and safely.
N/A	Complete removal of the DTM pickup line arrangement every time FPSO is off location.	Removes the hazard interference with other marine users.	Removal of the entire DTM pick-up line cannot be done using an ROV due to the type of fixings which are used to attach it to the DTM. Attachment of the rope to the DTM is a mechanical process only possible with hand operated tools. Thus, it could only be done by saturation divers. Cost of mobilising a vessel equipped for saturation diving to remove and reattach the pick-up line is estimated to be $1M. This control also removes the ability to undertake cost-effective maintenance activities on the DTM while NV is off station as the presence of the rope allows a smaller less expensive vessel (non- DP) to perform ROV integrity	**Rejected** Costs, safety risk and the removal of the ability to undertake hook-up maintenance activities on the DTM while the NV is off station, outweigh the environmental benefit.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			inspections on the DTM while the NV is off station. If the pick-up line is not present then any vessel-based maintenance activities which did occur would be required to be completed under Dynamic Positioning (DP). Typical cost differential of $250 – 500K depending on scope and duration.	
N/A	Visual inspection: helicopter-based monitoring of DTM pick up line arrangement when FPSO is off station for longer absences (e.g. shipyard campaign).	Should a whale become entangled, frequent visual inspections would result in early detection and the opportunity to free the whale	High cost associated with mobilising a helicopter. Helicopter rate $8,500/inspection at weekly intervals during whale migration periods. $8,500 x 26 weeks (to cover northern and southern migration periods) ~$ 221,000. A monitoring frequency greater than weekly would increase costs significantly. Aviation is considered to have inherently greater safety risks than vessel operations and outweighs the risk of whale entanglement. This control does not alter the likelihood of entanglement.	**Reject** - Cost of using existing on-contract helicopters for dedicated inspections on a frequent basis is high and with the added safety risks is disproportionate to the likelihood of a whale entanglement.
N/A	Visual inspection: spotter plane based monitoring.	Should a whale become entangled, frequent visual inspections would result in early detection	Assumed rate of $2000/inspection at weekly intervals during whale migration periods. $2000 x 26 weeks (to cover northern and	**Reject** – Costs outweigh the environmental benefit. Spotter planes are unable to meet the assurance criteria

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		and the opportunity to free the whale.	southern migration periods) ~$ 52,000 .Contracting a spotter plane must be done in accordance with Santos Aviation Standards. Contracting a spotter plane must be done in accordance with Santos Aviation Standards. Even though a spotter plane charter would not have Santos personnel nor other passengers on board during the visual inspection, the activity would still require an assurance process to be carried out. This control does not alter the likelihood of entanglement.	required by the Santos Aviation Standards for contracting aircraft.

7.2.4 Environmental Impact Assessment

Description – Marine Fauna Interactions	
Receptors	Threatened, migratory, and local fauna.
Consequence	II – Minor

Threatened, Migratory, and Local Fauna

In the event of a collision with fauna, there is the potential for injury or death to an individual. The number of receptors present in the operational area is expected to be limited to a small number of transient individuals.

Eight species of whale and one dolphin species may potentially occur within the predicted operational area (**Table 3-6**).

Blue, sei, fin, sperm and Southern right whales may transit through operational area and a pygmy blue whale BIA for distribution and a humpback whale migration BIA overlap. Impact to an individual may occur, however, impact at a population or ecosystem level is not anticipated.

Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) indicates that humpback whales are one of the most frequently reported whale species involved in vessel strikes worldwide (Laist *et al*., 2001; Jensen & Silber, 2003). The operational area overlaps the humpback whale migration BIA. However, the area of overall represents a small proportion of the BIA width and the likelihood of encounters is unlikely. The main migration path during the northward migration (July to October) of the humpback whale is centred along the 200 m bathymetric contour (Jenner et al., 2001), which unlikely to intercept the operational area. Although humpback whales may be

Description – Marine Fauna Interactions	
within the operational area and a BIA for humpback migration occurs over the operational area, an unplanned marine fauna interaction is not expected to interfere with their migration activity. Boat strike is recognised by the Approved Conservation Advice for *Rhincodon typus* (whale shark) (TSSC, 2015b) as one of the threats to their recovery. The operational area does not lie within a foraging BIA for whale shark and given the offshore location large numbers of species are not anticipated. It is however possible that individuals may transit through the operational area and therefore the potential for death or injury remains. The operational area is 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. It is possible that individual turtles may be encountered during NV vessel operations, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected. Boat strike and vessel disturbance are identified as potential threats to several marine fauna species in relevant Recovery Plan and Conservation Advice. With regards to the potential for impact on protected species as a result of entanglement with the pickup arrangement line, it is acknowledged that the presence of a buoy may present a limitation to an entangled whale to self-free itself, the addition of the buoy is to ensure that the rope streams on the sea surface, reducing the potential for the rope to become entangled on itself (bird-nest like structure). This tangling effect has been observed to occur during previous sail-away activities. The likelihood of a whale becoming entangled in a birds-nested rope is considered greater than the likelihood of a whale becoming entangled in a single strand of rope. Both the reduction of the length of line on the sea surface and the addition of the buoy attached to the DTM floating pick-up line is therefore considered to also reduce the risk of whale entanglement. Based on the risk matrix included in the current EP, following the inclusion of the controls listed above, the likelihood of a whale becoming entangled is considered Very Unlikely (risk score of 2) and the consequence was considered II-Minor (detectable but insignificant change to local population, industry or ecosystem factors. Localised effect with rapid recovery). Overall, there is the potential for death or injury of EPBC Act listed individual species, however as they would represent an individual within the local population it is not expected that it would result in a decreased population size. With controls in place the potential impact is *Minor*.	
Likelihood	C –Possible
The operational area overlaps humpback whale migration pathways and the BIA for pygmy blue whale distribution. No known aggregation areas (breeding, resting or calving) occur within the operational area and significant numbers of marine fauna are unlikely. There is generally low number of vessel activities associated with the operations of the NV Operations and vessels are stationary or moving very slowly while carrying out supporting activities (e.g. IMMR, tanker or FPSO support) and at <5 knots within the 500 m restricted zone. However the risk of collision with marine fauna is still *Possible* and has occurred before in industry. The vessel's size and underwater noise 'footprint' (refer **Section 6.1**) will alert marine fauna to its presence and generally illicit avoidance. Marine fauna approaching the vessels are expected to detour around them, and other vessels. The likelihood of a collision with marine fauna is *Possible*	
Residual Risk	The residual risk associated with this event is **Low**

7.2.5 Demonstration of ALARP

There are no alternatives to the use of the vessel and helicopters to undertake the NV Operations. The inherent likelihood of encountering fauna in the operational area is limited by the short duration of the activity and the separation from areas of high surface fauna density. With low vessel speeds and compliance with fauna interaction procedures, including Regulation 8 of the EPBC Regulations 2000, which aim to prevent adverse interactions of vessels with marine fauna, a fauna collision is considered very unlikely.

It should also be noted that the offshore remote location and water depths in the operational area reduce the probability of interactions with marine fauna.

Reducing the frequency or size of vessels is possible but would introduce disproportionate operational and safety risks; for example, the vessel is required to be of sufficient size and power to be able to efficiently and timely supply the necessities/services to maintain effective operation of the FPSO. Similarly, reducing or removing vessel and helicopter activities during known migration and aggregation periods of marine fauna is not a viable option as these activities are necessary for the safe and efficient NV operations, year round.

Visual inspections occur on the DTM pickup from a dedicated monitoring vessel 4 times a month during whale migration periods and from shared vessels when feasible result in early entanglement detection and the opportunity to free the whale. Other controls such as removing the DTM have additional costs, safety risk removes the ability to undertake hook-up maintenance activities on the DTM while the NV is off station. The use of spotter helicopters and planes were investigated; however the cost is high and with the added safety risks is disproportionate to the likelihood of a whale entanglement.

Santos has internal incident reporting systems and processes to manage any injury or death to marine fauna as a result of NV Operations. Implementing relevant EPBC procedures for interacting with EPBC listed marine fauna complies with the EPBC Regulations focus and is determined ALARP and acceptable given the location of the operational area and NV Operations.

No stakeholder concerns have been raised regarding this aspect and the proposed controls will reduce the residual level of risk to low and ALARP. Therefore, the low level of residual risk associated with marine fauna interactions is considered to be environmentally acceptable.

With the controls adopted, the assessed residual risk for this impact is low and cannot be reduced further. Additional control measures were considered but rejected since the associated cost / effort was grossly disproportionate to any benefit. It is considered therefore that the impact of the activities conducted is ALARP.

7.2.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Maximum marine fauna interaction residual risk ranked Low.
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with + Part 8 of the EPBC Regulations. Turtle/vessel interactions / disturbance arising from increased vessel traffic is recognised as one of several key impacts to marine turtles in the Recovery Plan for Marine Turtles Vessel disturbance / strike is threat within: + Conservation Management Plan for the Southern Right Whale 2011 – 2021 (2012),

	+ Approved Conservation Advice for Megaptera novaeangliae (humpback whale) (2015), + Approved Conservation Advice for Balaenoptera borealis (sei whale) (2015), + Conservation Management Plan for the Blue Whale 2015-2025 (2015) Control measures implemented will minimise the potential risks and impacts from the activity to relevant species identified in Recovery Plans and Conservation Advice Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this aspect.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Vessel presence and helicopter movements are required to carry out NV Operations and marine fauna interaction risk associated with vessel use is well understood and subject to regulation.

Application of the proposed management controls and adherence to Commonwealth regulations reduces the likelihood of interactions with marine fauna. While the potential exists for a collision to occur, it is considered unlikely. Vessels will be travelling at low speeds within the operational area, further reducing the likelihood of fauna strike. In the unlikely event that an impact did occur, it would be highly probable that only a single individual would be contacted (although it is noted that even if it is a single species, if it's a protected species the consequence will be more than minor in accordance with the Environmental Consequence Descriptors; therefore, the impact is considered to be ALARP and environmentally acceptable.

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this unplanned event from the NV Operations.

7.3 Release of Solid Objects

7.3.1 Description of Event

Event	The unplanned released of solid objects to the marine environment may include wastes or equipment. Non-hazardous wastes include general wastes such as scrap metals, packaging and dunnage, wood, cardboard, paper, and empty containers. The incorrect disposal could include intentional discharge of these items overboard through a lack of education on waste management practices or accidental discharge due to overfull bins, bins that are not covered or have been left open or wastes dropped during transfer between the FPSO and a vessel. Lifting of equipment and other objects on vessels and the FPSO is required for NV Operations. Dropped objects/lost equipment such as a tooling used during IMMR could also result in localised seabed disturbance.
Extent	**Localised**: Primarily within the operational area, noting that

	+ buoyant objects (e.g. plastic bags, hard hats) could drift beyond the operational area; and + non-buoyant dropped objects (non-hazardous solid) will likely sink to the seabed.
Duration	**Permanent**: Event could occur during life of EP.

7.3.2 Nature and Scale of Environmental Impacts

Potential Receptors: Benthic habitats, fish and sharks, marine mammals, marine reptiles and seabirds

Non-hazardous solids such as plastics have the potential to affect benthic environments and harm marine fauna through entanglement or ingestion. The greatest potential for impact is likely to arise from plastic waste / packaging that could be released and drift towards more sensitive shallow water habitats and shorelines which could have aggregations of sensitive species (e.g. turtles). Marine turtles and seabirds are particularly at risk from entanglement. The operational area is 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. However, presence of internesting flatbacks within the operational area are unlikely, given the water depths of the area compared to measured water depths of tagged internesting turtles. Marine turtles may mistake plastics for food; once ingested, plastics can damage internal tissues and inhibit physiological processes, which can both potentially result in fauna fatality. Floating non-biodegradable marine debris has been highlighted as a threat to marine turtles, whales, whale sharks and albatrosses/ giant petrels in the relevant Recovery Plans and Approved Conservation Advice (refer to **Table 3-8**). The Recovery Plans and Approved Conservation Advice as well as the Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018) have specified recovery actions to help combat this threat. Of relevance is the legislation for the prevention of garbage disposal from vessels.

The area of potential seabed disturbance due to a non-buoyant dropped objected (non-hazardous solid) would be restricted to the operational area. Dropped objects that sink could potentially impact benthic invertebrates or demersal fish. While soft sediment benthic habits will not be destroyed, disturbance of the communities on and within them (i.e. the epifauna and infauna) will occur in the event of a dropped object and depressions may remain on the seabed for some time after removal of the dropped object as it gradually infills over time. However, the soft sediment habitat within the operational area is not expected to have a particularly high abundance, diversity or unique composition of benthic invertebrates (**Section 3.2.2**). Any impact from sinking non-hazardous waste is likely to be negligible of an ecosystem of population level. While the operational area overlaps the Key Ecological Feature of Continental Slope Demersal Fish Communities, this community is not expected to be significantly impacted.

7.3.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No unplanned objects, emissions or discharges to sea or air [EPO-NV-09]

The control measures considered for this event are shown in **Table 7-4**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-4: Control Measures Evaluation for Discharge of Solid Objects

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
NV-CM-25	Garbage management	Reduces probability of garbage (waste) being accidentally discharged to sea from FPSO and vessels, reducing potential impacts to marine fauna. Provides compliance with Marine Order 95: Marine Pollution Prevention – Garbage.	Personnel cost of vessel audits and inspections, and in reporting discharge levels.	**Adopted** – benefits of ensuring vessel is compliant outweigh the minimal costs of personnel time and is a legislated requirement.
NV-CM-05	Vessels Planned Maintenance System	Reduces likelihood of dropped objects because lifting equipment is operating within its parameters.	Operational costs and labour/access requirements of undertaking equipment maintenance on vessels.	**Adopted** – Benefits of operating equipment within operational parameters will help reduce the likelihood of dropped objects.
NV-CM-14	Dropped object prevention controls	Minimises impacts and extent of seabed disturbance through procedures and standards for lifting / crane equipment inspection and maintenance and lifting procedures.	No additional costs to Santos other than negligible personnel costs of implementing.	**Adopted –** Environmental benefits outweigh the low costs of implementing measure.
NV-CM-15	Dropped object recovery	Requires dropped objects to be recovered (where safe and practicable to do so).	Additional personnel and vessel costs to plan and undertake if safe and practicable to do so.	**Adopted -** Benefits of recovering dropped objects where safe and practicable to do so outweighs the costs.
Additional Control Measures				
N/A	Eliminate lifting in field	Reduces the risk release of non-hazardous solid to the marine environment due to dropped object.	Eliminating lifting would affect production operations and safety.	**Rejected** – Not feasible to eliminate lifting.
N/A	Immediate removal of solid waste	Reduces the risk release of non-hazardous solid to	Substantial additional cost to NV Operations	**Rejected** – Cost outweighs the benefit.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
	from the operational area	the marine environment	through fuel cost and personnel time.	
N/A	Cessation of operations until all dropped objects are located / recovered	Would minimise potential for further disturbance due to dropped object potentially moving around on seabed causing further disturbance or long-term impacts.	Substantial additional cost to NV Operations due to downtime over and above value of equipment lost. Little benefit given water depths and sparse distribution of sensitive benthic habitats in operational area.	**Rejected** – Cost outweighs the benefit.

7.3.4 Environmental Impact Assessment

Description – Release of Solid Object	
Receptors	Threatened, migratory, and local fauna; Physical environment and habitats (benthic).
Consequence	I – Negligible

Threatened, Migratory, and Local Fauna

Relevant Recovery Plans and Conservation Advice (**Table 3-8**) has identified marine debris and pollution as a potential threat and established the Threat Abatement Plan for Marine Debris (2018

A release could cause localised impacts to water quality and the benthic environment. Ingestion of solid wastes by marine fauna could occur in small quantities. Blue, sei, fin, sperm and Southern right whales may transit through the operational area and a pygmy blue whale BIA for distribution and a humpback migration BIA overlap the operational area. Any accidental loss of non-hazardous solids to the environment would be small in size. Any impacts would be restricted to a small number of individuals, if any. As such there is the potential for impact is to a small proportion of a local population with no consequences for conservation status or reproductive success of species.

The operational area overlaps the humpback whale BIA, the main migration path during the northward migration (July to October) of the humpback whale is centred along the 200 m bathymetric contour (Jenner et al., 2001), which is unlikely to intercept the operational area where risk occurs Although humpback and pygmy blue whales may be exposed and a BIAs occur over the operational area, an unplanned discharge of non-hazardous waste (solids) is not expected to interfere with their migration activity. Any impact is expected to be at individual level only.

It is possible that individual turtles may come into contact with the release, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected. Any interaction would be *Negligible* and at individual level only.

Physical Environment and Habitats (benthic)

In the event of a dropped object or a non-hazardous solid sinking to the seabed, there will be localised and short-term damage to the seabed. The extent of the impact is limited to the size of the dropped object or non-hazardous solid released and given the size of standard materials used for NV operations, any impact is expected to be localised.

The seabed is likely to comprise soft sediments with little epifauna. Subsequently any impacts are predicted to be short-term in nature. Any impact to seabed through dropped objects which could not be recovered would result in a *Negligible* reduction in habitat area/function impacted.

The limited quantities associated with this event indicate that even in a worst-case release of solid waste, impacts to fauna would be limited to individuals and is not expected to result in a decrease of the local population size, the consequence level is therefore *Negligible.*	
Likelihood	D –Occasional
Control measures proposed ensure that the risk of dropped objects, lost equipment or release of non-hazardous solid waste to the environment has been minimised. The likelihood of transient marine fauna occurring in the operational area coincident with a release is limited and given the control measures in place, the likelihood of releasing non-hazardous solids to the environment resulting in a Negligible consequence is considered *Occasional,* in that it has occurred before in Santos.	
Residual Risk	The residual risk associated with this event is **Low**.

7.3.5 Demonstration of ALARP

Solid non-hazardous wastes will be generated onboard the FPSO and vessels during NV Operations. Segregation, compacting and storage of these wastes onboard in closed containers is considered good practice within the industry and meets AMSA Marine Orders / MARPOL requirements. Immediate removal of these wastes from the FPSO or vessels to shore-based facilities would result in additional fuel usage (emissions increase) or increases in the transfer of wastes between vessels (higher risk) and are not considered a practicable solution.

Lifting of objects on vessels and the FPSO is required for NV Operations. Lifting procedures and inspection/testing requirements for cranes and lifting equipment on the FPSO and vessels reduces the risk of dropped objects. If an object is dropped it will be recovered where safe and practicable to do so. Given the adoption of the industry standard management controls listed above, the risk of accidental discharge of solid non-hazardous wastes to the marine environment have been reduced to ALARP.

7.3.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Non-hazardous solid waste residual risk is ranked Low.
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with. + Marine Order 95 (Pollution prevention – Garbage) (vessels) + MARPOL Annex V (FPSO) A number of relevant Recovery Plans and Conservation Advice (Section 3.2.4.1) have identified marine debris and pollution as a potential threat. Control measures implemented will minimise the potential impacts from the activity to species identified in Recovery Plans and Approved Conservation Advice as well as the Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018) as having the potential to be

	impacted by non-hydrocarbon surface releases of solid material/wastes. Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this aspect.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The handling and use of non-hazardous solid materials is standard industry practice and the potential impacts well understood. This aspect will be managed consistent with relevant legislation, regulations and guidelines and the residual risks are low and ALARP.

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this unplanned event from the NV Operations.

With the control measures in place to prevent accidental releases and the negligible impacts predicted from these types of solids, the environmental risk of using and handling non-hazardous solids is considered acceptable.

7.4 Release of Materials Hazardous to the Marine Environment (solids and liquids)

7.4.1 Description of Event

Event	Hazardous materials used onboard the FPSO and vessels include: + hydrocarbons (low volumes of MDO); + mineral oil, hydraulic fluid and lube oils for operation and maintenance of moving parts used in engines, equipment (e.g. pumps, cranes, winches, power packs, generators) and ROVs; + process and cleaning chemical (solvents, cleaning agents); + contaminated materials (such as sorbents, filters and rags, NORM contaminated materials); + oil-contaminated sand and sludge; + used / waste acids and solvents; + batteries; + medical wastes; + paints and aerosol cans; and + fluorescent light tubes. These materials could potentially impact the marine environment, if incorrectly disposed of, lost overboard, or discharged accidentally significant quantities. Spills/leaks of chemicals and / or hydrocarbons onboard the FPSO or vessels may arise from equipment malfunction, corrosion of storage vessels or pipework and human errors during filling of storage vessels or portable equipment. The majority of chemicals stored onboard the FPSO are used during the production process. These and other chemicals onboard the FPSO are selected using the Operations Chemical Selection Evaluation and Approval Procedure (EA-91-II-10001), see **Section 2.8.9.3**. Production chemicals are delivered in transportable

	containers by support vessels and stored in bunded laydown areas on board the FPSO prior to transferring to bunded injection skid tanks. Sealed intermediate bulk containers (IBCs) are typically used to transfer large quantities of lube oil and chemicals between support vessels and the FPSO. The transfer of oils and chemicals between a support vessel and the FPSO has the potential to lead to a direct release into surface waters in the event of a dropped and ruptured container (up to 4 m^3 of lube oil or chemicals) or drums (up to 2.5 m^3 of hydraulic fluid). Vessels undertaking IMMR activities may store chemicals for subsea use. IMMR activity planned chemical use is discussed in **Section 6.5**. Accidental releases of small quantities of IMMR chemicals may occur (e.g. deck spills) and be released to the marine environment. Typically, volumes of such spills are small (< 20 L). Leaks or rupture of the ROV's hydraulic hoses may occur through equipment malfunction or line pinches which would lead to the loss of a small volume of hydraulic fluids directly to the marine environment. A maximum credible release of 50 L has been assumed based on multiple leaks of hydraulic fluid on an ROV. Oil-contaminated sand and sludge is occasionally recovered during normal operation and maintenance risk-based processing equipment; however they are not a significant ongoing source of waste as all production wells have downhole sand screens installed to minimise production of sands and sludges. Oil contaminated sand and sludge collected in the topsides equipment is separated and stored in suitable containers on the FPSO and transported onshore for appropriate treatment or disposal. Should a container be lost during transfer from the FPSO to the support vessel a maximum volume of 500 L of oil contaminated sludge could be lost to the marine environment. Diesel volumes beyond the diesel tanks located internally within the FPSO are small and associated with equipment such as the lifeboat and crane diesel tank. Small volumes of diesel may also be used on the FPSO and vessels to fuel equipment on deck. Equipment malfunction and operator error may lead to spill from this equipment. Spills of MDO during bunkering are discussed in **Section 7.9.** Hazardous solid wastes (batteries, medical waste, fluorescent light tubes etc.) will be segregated at source into recyclable and non-recyclable wastes and stored in clearly marked containers prior to transfer onshore. All waste materials not suitable for discharge to the environment, including hazardous wastes generated during the NV Operations are transported to shore for disposal or recycling. Environmental impacts from NORMs in PW disposed is **Section 6.7**. A maximum credible spill volume to the marine environment of 4 m^3 is assumed from complete loss of an IBC containing oil or chemicals during transfer between a vessel and the FPSO.
Extent	**Localised**: Any hazardous materials (solids and liquids) accidentally discharged within the operational area will either sink within the surrounding area, disperse rapidly within the operational area (in the case of small hazardous liquid leaks/spills) or potentially drift out of the area if the items are buoyant (e.g. empty containers, oily rags).
Duration	**Permanent**: Could occur during field life. The transfer of hazardous materials (including oils and chemicals) between a vessel and the FPSO can occur at a rate of approximately once fortnight. Project vessels are required less frequently, as per operational requirements.

7.4.2 Nature and Scale of Environmental Impacts

Potential Receptors: Benthic habitats, fish and sharks, marine mammals, marine reptiles and seabirds

Accidental disposal of hazardous materials into the marine environment will result in pollution and contamination of the marine environment, localised decline in water quality, toxic effects to marine fauna and potential injury to fauna.

Solid hazardous materials (e.g. batteries, used chemical containers) would likely sink to the seabed within the vicinity of the operational area. Such material could impact benthic invertebrates and demersal fishes associated with the soft sediment habitat through toxic effects of any bioavailable toxic chemicals released. The greatest potential for impact (in terms of quantity of chemicals) would be from dropped hazardous materials during bulk transfer operations between support vessels and the FPSO (e.g. packaged liquid chemical transfers). While toxic impacts could occur, it is unlikely that these would have an impact on species at an ecosystem or population level with any impacts likely to be restricted to the immediate vicinity; the habitat within and immediately around the operational area is ubiquitous on the NWS and the benthic invertebrate and fish species that it supports are not anticipated to be significantly impacted.

The operational area is 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA. However, presence of internesting flatback are unlikely, given the water depths of the area compared to measured water depths of tagged internesting turtles. Marine turtles may mistake buoyant waste for food; once ingested, plastics can damage internal tissues and inhibit physiological processes, which can both potentially result in fauna fatality. Floating non-biodegradable marine debris has been highlighted as a threat to marine turtles, whales, whale sharks and albatrosses/ giant petrels in the relevant Recovery Plans and Approved Conservation Advice (refer to **Table 3-8**). The Recovery Plans and Approved Conservation Advice as well as the Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018) have specified a number of recovery actions to help combat this threat.

More buoyant hazardous wastes such as oily rags, aerosol cans and contaminated packaging could also potentially drift out of the operational area in the direction of the prevailing wind and surface currents. Such wastes could potentially reach shallow waters and shorelines inshore of the operational area (e.g. the Ningaloo Coastline). It is considered however that there is a low potential for these materials to create a toxic impact to shallow water habitats and associated flora and fauna.

Small diesel spills will rapidly spread on the water surface, with the diesel expected to evaporate and disperse rapidly (NOAA, 2006) within the vicinity of the operational area. Lubricating and hydraulic oils will behave similarly to diesel if spilt to the marine environment, although lubricating oils are more viscous and so the spreading rate of a slick of these oils would be slightly slower. Hydraulic oils are medium oils of light to moderate viscosity and have a relatively rapid spreading rate and dissipate quickly in higher sea states.

A release of hazardous chemicals could potentially impact plankton, pelagic invertebrates, pelagic fish, marine mammals, marine reptiles and seabirds in the immediate vicinity of the release, however given the highly dispersive waters within the operational area, the extent of the water column (water depth >340m) and the relatively small potential volumes associated with such releases, rapid dilution is expected and concentrations are unlikely to persist for periods of time where impacts would likely be felt. The greatest potential for impact would likely be for passive or low mobility fauna such as plankton, pelagic invertebrates and small pelagic fishes which may be exposed for the greatest periods of time and likely have a permanent presence within the operational area. Large, more mobile fauna are likely to be transient within the operational area and toxic impacts are unlikely to occur to these species in the event of a small liquid hazardous hydrocarbon release.

Given the localised impacts in water quality from the discharge and the lack of any natural seabed features that would indicate a high abundance or diversity of demersal fishes within the operational area, it is believed that such a release would have a negligible impact on the demersal fish populations of the Continental Slope Demersal Fish Communities KEF.

7.4.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No unplanned objects, emissions or discharges to sea or air [EPO-NV-09].

The control measures considered for this event are shown in **Table 7-5**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-5: Control Measures Evaluation for Discharge of Materials Hazardous to the Marine Environment

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Control				
NV-CM-26	FPSO deck drain system and bunding	Reduces the likelihood of any oily/chemical content reaching the marine environment, from the FPSO.	Personnel and operational costs associated with construction and maintenance of offshore bunding and maintenance of bunding procedure	**Adopted** – benefit of the inspection to determine operational integrity outweigh the cost to undertake the inspection.
NV-CM-56	Hazardous chemical management	Reduces the risk of spills and leaks (discharges) to sea from FPSO and vessels by controlling the storage, handling and clean-up.	Personnel cost associated with implementation of procedures and permanent or temporary storage areas.	**Adopted** – Benefits of ensuring procedures are followed and measures implemented to reduce potential environmental risks and impacts outweigh costs.
NV-CM-57	General chemical management	Potential impacts to the environment are reduced through following correct procedures for the safe handling and storage of chemicals on FPSO and vessels.	Personnel costs associated with ensuring procedures are in place and implemented during inspections.	**Adopted** – Benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.
NV-CM-58	Spill response equipment	Provides a means to prevent any deck spills of hazardous liquids reaching the sea	Costs associated with stocking spill response equipment on vessels and FPSO	**Adopted** – benefits of stocking, using and maintaining spill response equipment outweighs the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
NV-CM-05	Vessel Planned Maintenance System	Reduces likelihood of dropped objects because lifting equipment is operating within its parameters	Operational costs and labour/access requirements of undertaking equipment maintenance on vessels	**Adopted** – Benefits of operating equipment within operational parameters will help reduce the likelihood of dropped objects.
NV-CM-59	Vessel spill response plan (SOPEP/SMPEP)	Implements response plans on board vessels to deal with unplanned hydrocarbon releases and spills quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents. Generally undertaken by vessel contractor so time for Santos personal to confirm and check SOPEP/SMPEP in place.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-60	Third-party ROV inspection and maintenance procedures	Maintenance and pre-deployment inspection on ROV completed as scheduled to reduce the risk of hydraulic fluid releases to the marine environment.	Additional personnel costs of ensuring procedures in place and followed.	**Adopted –** Benefits of ensuring procedures are followed and implemented to reduce potential environmental risks and impacts outweigh costs.
NV-CM-14	Dropped object prevention controls	Minimises risk of dropped object through procedures and standards for lifting equipment inspection and maintenance and lifting procedures.	No additional costs to Santos other than negligible personnel costs of implementing.	**Adopted –** Environmental benefits outweigh the low costs of implementing measure.
NV-CM-15	Dropped object recovery	Requires dropped objects to be recovered (where safe and practicable to do so).	Additional personnel and vessel costs to plan and undertake if safe and practicable to do so.	**Adopted -** Benefits of recovering dropped objects where safe and practicable to do so outweighs the costs.
Additional Control Measures				
N/A	Eliminate lifting in field	Reduces the risk release of non-hazardous solid to the marine	Eliminating lifting would affect production operations and safety.	**Rejected** – Not feasible to eliminate lifting

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		environment due to dropped object.		
N/A	Immediate removal of solid waste from the operational area	Reduces the risk release of non-hazardous solid to the marine environment	Substantial additional cost to NV Operations through fuel cost and personnel time.	**Rejected** – Cost outweighs the benefit
N/A	Cessation of operations until all dropped objects are located / recovered	Would minimise potential for further disturbance due to dropped object potentially moving around on seabed causing further disturbance or long-term impacts	Substantial additional cost to NV Operations due to downtime over and above value of equipment lost. Little benefit given water depths and sparse distribution of sensitive benthic habitats in operational area.	**Rejected** – Cost outweighs the benefit

7.4.4 Environmental Impact Assessment

Description – Release of Materials Hazardous to the Marine Environment	
Receptors	Threatened, migratory, and local fauna; Physical environment and habitats.
Consequence	I –Negligible

Threatened, Migratory, and Local Fauna

The susceptibility of marine fauna to hazardous materials is dependent on material (solid or liquid), volume, type and exposure duration. However, given that exposures would be limited in extent and duration due to the small volumes the impacts to receptors is not significant.

Blue, sei, fin, sperm and Southern Right whales may transit through the operational area and a pygmy blue whale BIA for distribution and humpback BIA for migration overlap the operational area. For marine mammals that may be exposed to the more toxic aromatic components of the minor hydrocarbon or chemical spills, toxic effects are considered unlikely since these species are mobile and therefore will not be constantly exposed for extended durations that would be required to cause any major toxic effects.

The operational area overlaps the humpback whale BIA, the main migration path during the northward migration (July to October) of the humpback whale is centred along the 200 m bathymetric contour (Jenner et al., 2001), which is unlikely to intercept the operational area where risk occurs Although humpback and pygmy blue whales may be exposed and BIAs occur over the operational area, an unplanned discharge of hazardous material (solids and liquids) is not expected to interfere with their migration activity. Any impact is expected to be at individual behavioural level only.

Floating non-biodegradable marine debris has been highlighted as a threat to marine turtles, whales, whale sharks and albatrosses/ giant petrels in the relevant Recovery Plans and Approved Conservation Advice (refer to **Table 3-8**) and chemical and terrestrial discharge and marine pollution are identified as potential threats to turtles within Recovery plan for marine turtles in Australia 2017-2027 (**Table 3-8).** With control measures in place, the activity will be conducted in a manner that reduces potential impacts. Impacts may occur small proportion (individuals) of a local population with no consequences for conservation status or reproductive success.

Description – Release of Materials Hazardous to the Marine Environment	
It is possible that individual turtles may come into contact with the release, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected and significant impacts to population will not occur. Impacts may occur small proportion (individuals) of a local population with no consequences for conservation status or reproductive success Toxic impacts are not expected to the benthic community due to the water depths. <u>Physical Environment and Habitats</u> The small volumes and dilution and dispersion from natural weathering processes such as ocean currents are such that spills will be limited in area and duration. Releases of hazardous materials to the marine environment will impact local water quality for a short period of time whilst the release disperses. Impact to water quality will be *Negligible*. Given that an unplanned discharge of hazardous material (solids and liquids) would not result in a decreased population size at a local or regional scale and impacts will short term behavioural impacts to individuals, it is expected that a discharge of this nature would result in a *Negligible* consequence.	
Likelihood	D –Occasional
Control measures proposed ensure that the risk of or release hazardous materials to the environment has been minimised. The likelihood of transient marine fauna occurring in the operational area coincident with a release is limited and given the control measures in place, the likelihood of releasing hazardous materials to the environment resulting in a negligible consequence is considered *Occasional,* in that it has occurred o before in Santos or could occur within months to years.	
Residual Risk	The residual risk associated with this event is **Low**.

7.4.5 Demonstration of ALARP

The use of hazardous materials is integral to the safe production, processing and export of the hydrocarbons and cannot be eliminated. Industry-standard technologies are not available to eliminate the use of chemicals or fluids on-board (e.g. hydraulic oils). Procedures are in place for the management of hazardous materials to control their storage and handling.

Only volumes of hazardous materials as required for maintaining an efficient production process and vessel capabilities will be stored or handled on-board the FPSO and vessels. The FPSO and vessels will implement safeguards, as per relevant AMSA Marine Orders / MARPOL requirements. Such safeguards may include (but not limited to) designated storage and handling areas, correct stowage, accurate labelling and marking, Safety Data Sheet (SDS) information, spill clean-up equipment and containment.

Lifting of objects on vessels and the FPSO is required for NV Operations. If an object is dropped it will be recovered where safe and practicable to do so. Lifting procedures and inspection/testing requirements for cranes and lifting equipment on the FPSO and vessels reduces the risk of dropped objects. Given the adoption of the industry standard management controls listed above, the risk of accidental discharge of hazardous materials to the marine environment has been reduced to ALARP.

The likelihood of small spills of diesel from leaking vessel, pipework or from spills during manual handling is reduced by regular inspection and maintenance of equipment onboard the FPSO and vessels. Containment of small spills from bunding, inherent in the design of these vessels and from spill containment kits onboard these vessels provides a barrier to any spills reaching the marine environment. The inspection and maintenance of bunding and drainage systems and of spill response kits provides assurance that these are available to contain spills in the event of a small leak. It is considered that barriers in place to contain spills would prevent spills from reaching the marine environment and thus it is considered that there are no further controls that would offer a further benefit to the environment.

During the NV Operations, given the adoption of the industry standard management controls listed above it is considered that all practicable measures have been implemented to ensure the likelihood of hazardous materials being discharged to the marine environment have been reduced to ALARP.

7.4.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Maximum minor hydrocarbon spill residual risk is ranked Low.
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – Activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes - Management consistent with: + Marine Order 95 (Pollution prevention – Garbage) + Marine Order 91 (Marine pollution prevention – oil) + MARPOL Annex I (FPSO) + MARPOL Annex IV (FPSO). A number of relevant Recovery Plans and Conservation Advice (**Section 3.2.4.1**) have identified marine debris and pollution as a potential threat. Control measures implemented will minimise the potential impacts from the activity to species identified in Recovery Plans and Approved Conservation Advice as well as the Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018) as having the potential to be impacted by non-hydrocarbon surface releases of solid material/wastes. Activity in accordance with EPBC approval conditions (EPBC 2007/3213).
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised by stakeholders for this event.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The handling and use of hazardous (liquids and solid) materials is standard industry practice and the potential impacts well understood. This aspect will be managed consistent with relevant legislation, regulations and guidelines and the residual risks are Low and ALARP.

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this regarding this unplanned event from the NV Operations.

With the control measures in place to prevent accidental releases and the negligible impacts predicted from these types of solids, the environmental risk of using and handling hazardous materials (liquids and solids) is considered acceptable.

7.5 Overview of Unplanned Release of Hydrocarbons

7.5.1 Credible Release Scenarios

Unplanned events may occur during the operation of the NV FPSO and associated activities, resulting in the potential release of hydrocarbons (Van Gogh crude blend, MDO, HFO and dry gas) to the marine environment. The release scenarios assessed in **Sections 7.6** to **7.10.** In addition, a release of dry gas has been discussed in **Section 7.11**.

7.5.2 Release Scenario Selection

To identify the release scenarios that were considered credible for the NV Operations a broad range of potential scenarios were assessed as described below:

+ Subsea release of hydrocarbons from a production well;
+ Subsea release of hydrocarbons from the subsea system;
+ Surface release of Van Gogh crude blend;
+ Surface release of marine diesel (MDO);
+ Surface release of heavy fuel oil (HFO); and
+ Subsea release of dry gas.

Table 7-6 presents the Maximum Credible Scenario (MCS) scenarios for each of release scenarios above. Further details of the MCS scenarios and scenarios of lesser magnitude have been discussed in **Sections 7.6** to **7.11**.

Table 7-6: Summary of Maximum Credible Spill Scenarios

<table>
<tr><th>MCS Scenario</th><th>Hydrocarbon Type</th><th>Maximum Credible Volume</th><th>Comment</th><th>EP Section</th></tr>
<tr><td>Subsea release of Van Gogh crude blend from a production well as a result of an external impact, such as anchor/chain drag.</td><td rowspan="3">Van Gogh crude blend</td><td>10,236 m³ over 100 days</td><td rowspan="2">Maximum credible volume modelled (see Note 1, below) – with highest flow potential derived by combining the highest reservoir flow parameters for the wells.</td><td>7.6</td></tr>
<tr><td>Subsea release of Van Gogh crude blend from a subsea system rupture due to external impact</td><td>1,681 m³ over 24 hours</td><td>7.7</td></tr>
<tr><td>Surface release of Van Gogh crude blend from the FPSO or offtake tanker due to an external impact (vessel collision) which ruptures a crude tank.</td><td>8,630 m³ over 1 hour</td><td>Maximum credible volume based on FPSO crude tanks, with the largest tank having a capacity of 8,630 m³.</td><td>7.8</td></tr>
</table>

MCS Scenario	Hydrocarbon Type	Maximum Credible Volume	Comment	EP Section
Surface release of MDO from an FPSO or vessel as a result of an external impact (vessel collision) which ruptures an MDO tank.	MDO	1,519 m^3 over 1 hour	Maximum credible volume based on FPSO MDO bunker tanks, with the largest bunker tank having a capacity of 1,519 m^3	**7.9**
A surface release of HFO from the offtake tanker as a result of external impact (vessel collision) which ruptures an HFO tank on the offtake tanker.	HFO	950 m^3 over 1 hour	Maximum credible volume based on offtake tanker HFO tanks, with the largest tank having a capacity of 950 m^3	**7.10**
Subsea dry gas release from a gas production well as a result of external impact (such as anchor /chain drag).	Dry gas	233 MM scfs dry gas over a 100 day period	Maximum credible volume based on highest reservoir flow parameters for the wells.	**7.11**

Note 1:

The MCS scenarios presented above were based on the Santos Ningaloo Vision Operations – Worst Case Credible Hydrocarbons Spill Scenarios: Van Gogh, Coniston, Novara Technical File Note (TFN), (NV-22-II-20001) and Ningaloo Vision Operations – Worst Case Credible Hydrocarbon Release Scenarios: Production and Gas Injection Lines TFN (NV-22-II-20002). Stochastic hydrocarbon dispersion and fate modelling undertaken to inform the environmental impact and risk assessment and to assist with emergency planning was based on maximum release volumes provided in the TFN.

Spill modelling was undertaken for the maximum credible spills (MCS) presented in **Table 7-6** (excluding dry gas release) by RPS during 2019 to support the EP submission (RPS, 2019).

7.5.2.1 Non-credible Scenarios

A number of scenarios were discussed were considered but determined non-credible, these are detailed below:

Overfilling of the offtake tanker cargo during crude transfer

This scenario evaluated an accidental release of Van Gogh crude blend to the marine environment from overfilling of the offtake tanker cargo tank and was ruled out due to the large number of controls in place and the only vent path being via Inert Gas vents which would vent any overfill fluids onto the tank deck. Controls include but are not limited to slowing load rates when topping off tanks, electronic and manual systems to report on the sullage of the tanks being topped off, independent high level alarm in the cargo tanks which set off an audible alarm in the cargo control room when the Safe Fill Level of tank capacity is reached. The vessel is continuously manned and any small volumes of fluids released would be collected within the scuppers and open drains system resulting in no release to the environment.

Vessel grounding

Given the offshore location of the operational area and water depths, vessel grounding is not considered a credible risk.

7.5.3 Spill Modelling Overview

Oil spill modelling was carried out with SINTEF's Oil Spill Contingency and Response (OSCAR) system (version 10.0.1). OSCAR is a system of integrated models to quantitatively assess the fate and transport of hydrocarbons in the marine environment, as well as evaluate the efficacy of response measures. OSCAR provides an integrated hydrocarbon transport and weathering model that accounts for hydrocarbon advection, dispersion, surface spreading, entrainment, dissolution, biodegradation, emulsification, volatilisation and shoreline interaction.

Three-dimensional (3D) OSCAR modelling was undertaken in stochastic mode (total of 150 realisations per scenario) with start dates spaced approximately fortnightly over a five year period. Inputs into the model were sourced from HYCOM (regional ocean currents, temperature and salinity profiles), TPXO7.2 (tidal currents) and NCEP/NCAR (regional winds).

Table 7-7 provides details on the model input specifications for the modelled scenarios.

Table 7-7: Model Input Specifications

Parameter	Scenario				
	Subsea hydrocarbon (well)	Subsea hydrocarbon (subsea system)	Surface hydrocarbon	Surface MDO	Surface HFO
Location	Van Gogh Drill Centres	FPSO Location			
Depth of Spill (m)	340	340	Surface		
Hydrocarbon type	Van Gogh crude blend			MDO	HFO
Release duration	100 days	24 hours	1 hours	1 hours	1 hours
Timing of release risk period	All months				
Runs	150				

7.5.3.1 Weathering Modelling

Weathering modelling was undertaken with the SINTEF Oil Weathering Model (OWM). OWM predicts the weathering (i.e. mass balance partitioning) of hydrocarbons under steady-state met-ocean conditions. OWM simulations were run for sustained wind speeds of 1 m/s (low winds), 5 m/s (moderate winds) and 10 m/s (high winds). The simulations are based on a test case of 100 m^3 of hydrocarbon released instantaneously onto the sea surface.

7.5.3.2 Hydrocarbon Specifications for Modelling – Crude Analogue

Oil Spill Modelling was undertaken by a third party provider using the OSCAR model. The OSCAR model does not allow direct modelling of the Van Gogh crude blend assay (**Table 7-8)**, rather it requires selection of a pre-defined oil for modelling. OSCAR contains a library of over 120 hydrocarbon analogues to choose from. All of these analogues have undergone extensive laboratory testing to define the weathering behaviour of the oil under a range of conditions. As such, each oil has a unique and validated weathering algorithm that governs the oil behaviour in the model. The approach with OSCAR is to select a hydrocarbon analogue from the oil library that most closely matches the given hydrocarbon assay (Van Gogh Crude). The selection is made by considering the whole crude properties and the distillation curve. This approach ensures the oil analogue used in the modelling will weather like a known real oil. Based on these factors, Linerle was determined as the most appropriate analogue for Van Gogh crude blend.

A comparison between the two crude properties (Linerle and Van Gogh crude blend) (**Table 7-8**) indicates the following:

- The specific gravity, API gravity and pour point of Linerle match very well with Van Gogh crude blend.
- The wax content of 0.27% is low, and within the range (<5%) reported for Van Gogh crude blend.
- The asphaltene content of Linerle (0.77%) is higher than the <0.5% reported for Van Gogh crude blend. Linerle may therefore have a slightly higher tendency to form emulsions relative to Van Gogh crude blend, which makes it a conservative oil analogue selection.
- The viscosity of Linerle at 20°C (1,470 cSt) is significantly higher than that of Van Gogh crude blend at 70°C (39 cSt). However, because of the disparity in the temperatures of these viscosity values, comparison of viscosity is uncertain.

Table 7-8: Comparison of Properties of Van Gogh Crude Blend and SINTEF Linerle (GHD, 2019)

Property	Van Gogh crude blend	Linerle
API Gravity	17	17
Specific Gravity	0.9523	0.953
Pour Point (°C)	-15	-15
Viscosity (cSt)	31.21 (@70°C)	1,470 (@20 °C)
Wax Content (%)	<5	0.27
Asphaltene (%)	<0.5	0.77

The wax content of Van Gogh crude blend is reported as <5% in the assay report. This is the lower limit of detection for the test undertaken on this assay (ASTM UOP46-85). There is insufficient information to determine if the modelling analogue (Linerle – wax content of 0.27%) has higher or lower wax content than Van Gogh Crude. Further, the asphaltene content of the adopted modelling analogue (Linerle – 0.77%) is higher than Van Gogh Crude (<0.5%), which (if all other factors are held being equal) would yield Linerle more prone to emulsification and slower weathering in comparison to Van Gogh Crude. In summary, it is unclear whether there is a difference in wax content between Linerle and Van Gogh Crude, however it is known that Linerle has the higher asphaltene content. As such, Linerle is considered to be a more conservative (i.e. environmentally persistent) oil on the basis of the information.

A comparison of the distillation curves of Linerle and Van Gogh crude blend is presented in **Figure 7-1**. The distillation curve is derived from laboratory tests to determine the percentage of hydrocarbon evaporated (recovered) when heated to various temperatures (or ‘cuts’). Lighter oil components evaporate under lower temperatures, whereas heavier oil components have a greater tendency to remain in liquid state, requiring higher temperatures to evaporate. This is analogous to oil weathering in the marine environment, whereby lighter components have a higher tendency to evaporate, dissolve or decay, and heavier components tend to persist as liquid hydrocarbon for extended durations. The distillation curve, therefore, provides a reasonable prediction of the relative proportions of hydrocarbon components that will have rapid rates of weathering and the relative proportions that will persist. The comparison of the distillation curves indicates very good agreement between Linerle and Van Gogh crude blend, indicating that the oils are likely to weather in a similar manner in the marine environment.

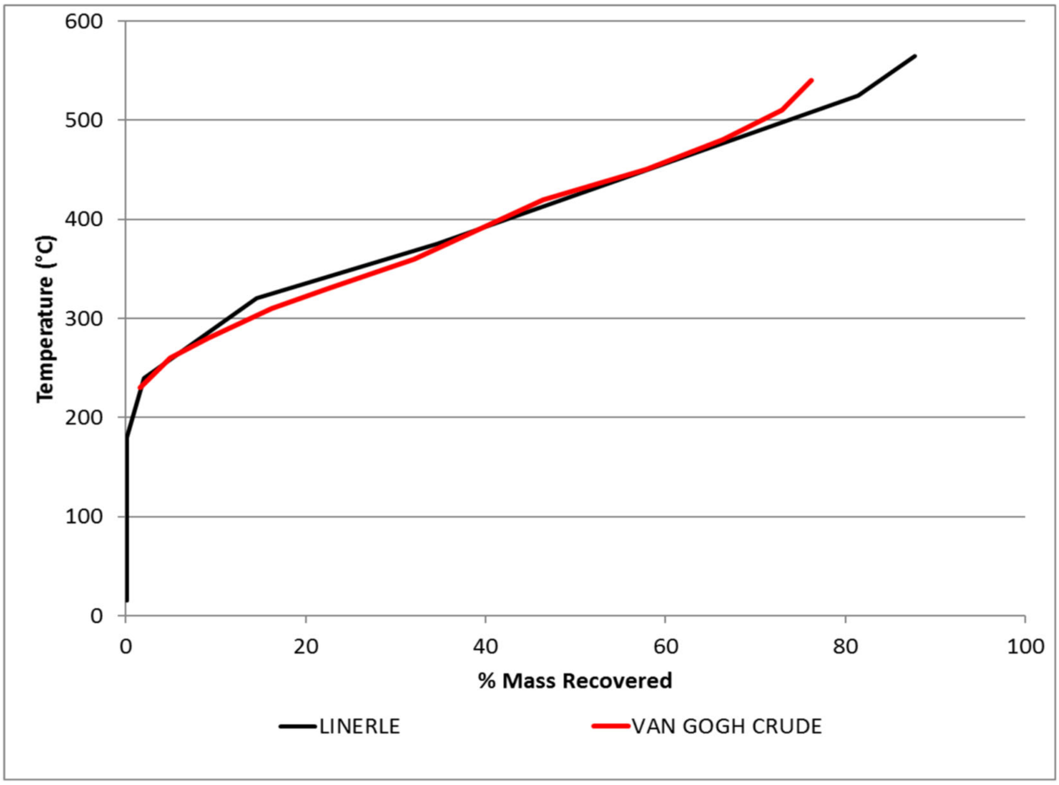

Figure 7-1: Comparison of distillation curves for Van Gogh and SINTEF Linerle (GHD, 2019)

7.5.4 Hydrocarbon Characteristics

Table 7-9 and **Table 7-10** provides a summary of characteristics of hydrocarbons relevant to the credible spill scenarios identified. **Appendix C** provides full assay data on the Van Gogh crude blend.

7.5.4.1 Van Gogh crude blend

Assay data shows the Van Gogh crude blend (**Table 7-9)** is biodegradable and contain a very small proportion of volatiles (<6%), a relatively low proportion of semi-volatile components and a high proportion of persistent compounds (68%). The blend has negligible proportion of aromatic compounds (<1%) and wax content (<5%).

Van Gogh crude blend can be categorised as a heavy Group IV oil (AMSA, 2015). These are fluid at winter and summer sea temperatures but are relatively viscous without forming stable emulsions as fresh oil. They have a high flash point that presents a low fire and explosion hazard when fresh.

7.5.4.2 Heavy Fuel Oil

Characteristics of HFO were extracted from the RPS Group oil database for similar operational temperatures to the North West Shelf (**Table 7-10**). HFO is a manufactured blend of hydrocarbons largely composed of low-volatile and persistent hydrocarbons to which a small proportion of higher volatility components are added. The oil has a low percentage of volatile and semi-volatile components (a total of < 6%). Approximately 11% of the volume has low volatility (boiling point between 265 and 380°C), that would require weeks to evaporate. A further 83% is composed of non-volatile components (boiling point greater than 380°C), which will not evaporate under typical environmental conditions that occur on the North West Shelf. The soluble aromatic hydrocarbons represent a low proportion of the volume of HFO, at approximately 2.2%.

HFO has high viscosity (> 3000 cSt) when fresh and the viscosity will rise through evaporation of lighter components and, consequently, will not spread as rapidly as less viscous oil types. Moreover, HFO can take up water at a ratio of 30-70% of the oil volume to form a water-in-oil emulsion (mousse), which will result in increased viscosity of the mixture. This emulsification process will inhibit evaporation rates for the oil and increase the volume of oily waste.

7.5.4.3 Marine Diesel

ITOPF (2011) and Australian Maritime Oil Spill Centre-AMOSC (2011) categorises diesel as a light group II hydrocarbon. In the marine environment, a 5% residual of the total quantity of diesel spilt will remain after the volatilisation and solubilisation processes associated with weathering (**Table 7-10).**

Table 7-9: Summary Characteristics of Van Gogh Crude Blend

Test	Unit	Whole crude	Cut Range					
			IBP – 230 °C	IBP – 260 °C	230 – 360 °C	260 – 230 °C	360 – 540°C	Residue 360 °C +
Fraction distillation	% mass		1.5	5.3	30.5	26.7	44.2	23.8
	% volume		1.7	5.9	32.0	27.8	43.7	66.3
Density @ 15 °C	Kg/l	0.9523	0.8738	0.8875	0.9124	0.9153	0.9631	0.9770
API gravity	°API	17.0	30.4	27.8	23.5	23	15.3	13.2
Asphaltenes	% mass	<0.5						
Viscosity @20 °C	cSt		3.235	4.507				
Viscosity @70 °C	cSt	31.21			3.571	4.056		
Wax Content	% mass	<5.0						
Aromatics (BTEX)	mg/l	<0.1						

Source: Intertek (2018)

Table 7-10: Characteristics of MDO and HFO

Hydrocarbon type	Initial density	Viscosity (cP)	Component	Volatiles (%)	Semi-volatiles (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			Boiling Points (°C)	<180 C4 to C10	180-265 C11 to C15	265 – 380 C16 to C20	>380 > C20	Of whole oil < 380
				NON-PERSISTENT			PERSISTENT	
MDO	0.8368 g/cm^3 @15°C	4 @15°C	% of total	6.0	34.6	54.4	<5	3.0
HFO	974.9 g/cm^3 @25°C	3,180 @25°C		1.0	4.9	11.3	82.8	2.2

Source: APASA (2013b)

7.5.5 Hydrocarbon Exposure Values

To inform the impact assessment it is important to understand the concentrations of hydrocarbons within the EMBA after a spill. To do this NOPSEMA recommends identifying hydrocarbon exposure values that broadly reflect the range of consequences that could occur at certain concentrations (NOPSEMA, 2019). The exposure values that have been applied to this EP are described below.

The EMBA shown in **Figure 3-1** was identified using low exposure values. These low exposure values are not considered to be representative of a biological impact but they are adequate for identifying the full range of environmental receptors that might be contacted by surface and/or subsurface hydrocarbons (NOPSEMA, 2019).

To inform impact assessment, exposure values that may be representative of biological impact have also been identified. These are called “moderate exposure values” and “high exposure values”. Moderate and high exposure values are modelled to identify the receptors contacted by surface, subsurface (entrained hydrocarbon and dissolved aromatic hydrocarbons), and shoreline accumulation.

Determining exposure values that may be representative of biological impact is complex since the degree of impact will depend on the sensitivity of the receptors contacted, the duration of the exposure and the toxicity of the hydrocarbon type making the contact. The toxicity of a hydrocarbon will also change over time, due to weathering processes altering the composition of the hydrocarbon. To identify appropriate exposure values Santos have considered the advice provided by NOPSEMA Bulletin #1 Oil Spill Modelling (April, 2019) and scientific literature. The selected hydrocarbon exposure values are discussed in **Table 7-11, Table 7-12**, **Table 7-13** and **Table 7-14**, these tables explain how the exposure value is relevant to the risk evaluation and provides context on how that exposure value is used to inform response planning (which is addressed further in the NV Operations OPEP).

Table 7-11: Surface Oil Exposure Values

Surface Oil Concentration (g/m^2)	Exposure Value	Description
1	Low	**Risk Evaluation** It is recognised that a lower surface oil concentration of 1 g/m^2 (equivalent to a thickness of 0.001 mm or 1 ml of oil per m^2) is visible as a rainbow sheen on the sea surface. Although this is lower than the exposure value for ecological impacts, it may be relevant to socio-economic receptors and has been used as the exposure value to define the spatial extent of the environment that might be contacted (EMBA) from surface oil. **Response Planning** Contact at 1 g/m^2 (as predicted by oil spill trajectory modelling) is used as a conservative trigger for activating scientific monitoring plans as detailed in the OPEP.
10	Moderate	**Risk Evaluation** There is a paucity of data on surface oil concentrations with respect to impacts to marine organisms. Hydrocarbon concentrations for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at about 10–25 g/m^2 (French et al., 1999; Koops et al., 2004; NOAA, 1996). The impact of surface oil on birds is better understood than on other receptors. A conservative exposure value of 10 g/m^2 has been applied to impact assessment from surface oil in **Section 7.6** to **7.10** of this EP. Although based on birds, this hydrocarbon exposure value is also considered appropriate for turtles, sea snakes and marine mammals (NRDAMCME, 1997). **Response Planning**

		Contact at 10 g/m² is not specifically used for spill response planning.
50	High	**Risk Evaluation** At greater thicknesses the potential for impact of surface oil to wildlife increases. All other things being equal, contact to wildlife by surface oil at 50 g/m² is expected to result in a greater impact. **Response Planning** Containment and recovery effectiveness drops significantly with reduced oil thickness (McKinney *et al.*, 2017; NOAA, 2014). McKinney *et al.* (2017) tested the effectiveness of various oil skimmers at various oil thicknesses. Their results showed that the oil recovery rate of skimmers dropped significantly when oil thickness was less than 50 g/m²-(less than Bonn Agreement Code 4). Hence, 50g/m² has been set as a guide for planning effective containment and recovery operations. Similarly surface oil >50 g/m² (Bonn Agreement Code 4/5 and equivalent to oil observed as discontinuous or continuous true colour) is considered to be a lower limit for effective dispersant operations and is therefore considered for planning.

Table 7-12: Shoreline Hydrocarbon Accumulation Exposure Values

Shoreline Accumulation (g/m²)	Exposure Value	Description
10	Low	**Risk Evaluation** An accumulated concentration of oil above 10 g/m² on shorelines is considered to represent a level of socio-economic effect (NOPSEMA, 2019).– e.g. reduction in visual amenity of shorelines. This value has been used in previous studies to represent a low contact value for interpreting shoreline accumulation modelling results (French-McCay, 2005, 2006). **Response Planning** Not specifically used for response planning because below the limit that can be effectively cleaned.
100	Moderate	**Risk Evaluation** The impact exposure value concentration for exposure to hydrocarbons stranded on shorelines is derived from levels likely to cause adverse impacts to marine or coastal fauna and habitats. These habitats and marine fauna known to use shorelines are most at risk of exposure to shoreline accumulations of oil, due to smothering of intertidal habitats (such as mangroves and emergent coral reefs) and coating of marine fauna. Environmental risk assessment studies (French-McCay, 2009) report that an oil thickness of 0.1 mm (100 g/m²) on shorelines is assumed as the lethal exposure value for invertebrates on hard substrates (rocky, artificial or man-made) and sediments (mud, silt, sand or gravel) in intertidal habitats. A conservative exposure value of 100 g/m² has been applied for impact assessment from shoreline accumulation of hydrocarbons in **Section 7.6** to **7.10** of this EP. **Response Planning** A shoreline concentration of 100 g/m², or above, is likely to be representative of the minimum limit that the oil can be effectively cleaned according (AMSA, 2015; NOPSEMA, 2019) and is therefore used as a guide for shoreline clean-up planning. This exposure value equates to approximately ½ a cup of oil per square meter of shoreline contacted.

1,000	High	**Risk Evaluation** At greater thicknesses the potential for impact of accumulated oil to shoreline receptors increases. All other things being equal, accumulation of oil above 1,000 g/m^2 is expected to result in a greater impact. **Response Planning** As oil increases in thickness the effectiveness of oil recovery techniques increases. This value can therefore be used to prioritise oil recovery efforts, assuming oil recovery is deemed to have an environmental benefit.

Table 7-13: Dissolved Hydrocarbon Exposure Values

Dissolved hydrocarbons (ppb)	Exposure Value	Description
10	Low	**Risk Evaluation** Dissolved Hydrocarbons (also referred to as dissolved WAF or Dissolved Aromatic Hydrocarbons (DAH)) include the monoaromatic hydrocarbons (MAHs) (compounds with a single benzene ring such as BTEX [benzene, toluene, ethyl benzene, and xylenes]) and polycyclic aromatic hydrocarbons (PAHs) (compounds with multiple benzene rings such as naphthalenes and phenanthrenes). These compounds have a greater bioavailability that other components of oil and are considered to be main contributors to oil toxicity. The toxicity of dissolved hydrocarbons is a function of the concentration and the duration of exposure by sensitive receptors with greater concentration and exposure time causing more sever impacts. Typically tests of toxicity done under laboratory conditions measure toxicity as proportion of test organisms affected (e.g. 50% mortality or LC50) at the end of a set time period, often 48 or 96 hours. French-McCay (2002) in a review of literature, reported LC50 for dissolved PAHs with 96 h exposure, range between 30 ppb for sensitive species (2.5th-percentile species) and 2,260 ppb for insensitive species (97.5th-percentile species), with an average of about 250 ppb. The range of LC50s for PAHs obtained under turbulent conditions (this includes fine oil droplets) was 6 ppb to 410 ppb with an average of 50 ppb (French-McCay, 2002). The dissolved hydrocarbon 10 ppb exposure value has been used to inform the EMBA within **Section 7.6** to **7.10**. An exposure value of 10 ppb is appropriate as it is concentration that could have some potential negative effect on marine organisms. **Response Planning** Contact at 10 ppb (as predicted by oil spill trajectory modelling) is used as a trigger for activating scientific monitoring plans as detailed in the OPEP. Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers (NOPSEMA, 2019).
50	Moderate	**Risk Evaluation** Approximates potential toxic effects, particularly sublethal effects to sensitive species (refer to above text). Consistent with NOPSEMA (2019). For most marine organisms, a concentration of between 50 and 400 ppb is considered to be more appropriate for risk evaluation. **Response Planning** Encompassed by response to 10ppb. There no different response planning for higher exposure values.
400	High	**Risk Evaluation**

		Approximates toxic effects including lethal effects to sensitive species (NOPSEMA, 2019). **Response Planning** Encompassed by response to 10ppb. There no different response planning for higher exposure values.

Table 7-14: Entrained Hydrocarbon Exposure Values

Entrained hydrocarbons (ppb)	Exposure Value	Description
10	Low	**Risk Evaluation** Entrained hydrocarbons (also referred to as total WAF), as opposed to dissolved, are oil droplets suspended in the water column and insoluble. Entrained hydrocarbons are not as bioavailable to marine organisms compared to DAHs and on that basis are considered to be a less toxic, especially over shorter exposure time frames. Entrained hydrocarbons still have potential effects on marine organisms through direct contact with exposed tissues and ingestion (NRC, 2005) however the level of exposure causing effects is considered to be considerably higher than for dissolved hydrocarbons. Much of the published scientific literature does not provide sufficient information to determine if toxicity is caused by entrained hydrocarbons, but rather the toxicity of total oils which includes both dissolved and entrained components. Variations in the methodology of the total water accommodated fraction (TWAF (entrained and dissolved)) may account for much of the observed wide variation in reported exposure values, which also depend on the test organism types, duration of exposure, oil type and the initial oil concentration. Total oil toxicity acute effects of total oil as LC50 for molluscs range from 500 to 2,000 ppb (Clark et al., 2001; Long and Holdway, 2002). A wider range of LC50 values have been reported for species of crustacea and fish from 100 to 258,000,000 ppb (Gulec et al., 1997; Gulec and Holdway, 2000; Clark et al., 2001) and 45 to 465,000,000 ppb (Gulec and Holdway, 2000; Barron et al., 2004), respectively. The 10 ppb exposure value represents the very lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC (2018) water quality guidelines. This is consistent with NOPSEMA (2019) guidance. **Response Planning** Contact at 10 ppb (as predicted by oil spill trajectory modelling) is used as a trigger for activating scientific monitoring plans as detailed in the OPEP. Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers (NOPSEMA, 2019).
100	Moderate	**Risk Evaluation** The 100 ppb exposure value is considered to be representative of sub-lethal impacts to most species and lethal impacts to sensitive species based on toxicity testing as described above. This is considered conservative as toxicity to marine organisms from oil is likely to be driven by the more bioavailable dissolved aromatic fraction, which is typically not differentiated from entrained hydrocarbon in toxicity tests using water accommodated fractions (WAFs). Given entrained hydrocarbon is expected to have lower toxicity than dissolved aromatics, especially over time periods where these soluble fractions have dissoluted from entrained hydrocarbon, the moderate exposure value is considered appropriate for risk evaluation.

		The entrained hydrocarbon 100 ppb exposure value has been used to inform the risk assessments within **Section 7.6** to **7.10**. **Response Planning** Encompassed by response to 10ppb. There no different response planning for higher exposure values.

7.5.6 Spill Risk Assessment Approach

The spill risk assessment approach adopted is based on the Santos Oil Spill Risk Assessment and Response Planning Procedure (QE-91-II-20003). The procedure describes the spill risk assessment process as follows:

A consistent risk assessment approach is applied to each unplanned hydrocarbon release scenario in **Section 7.6** to **Section 7.10**). The spill risk assessment approach is based on the Santos Oil Spill Risk Assessment and Response Planning Procedure (QE-91-II-20003). The procedure describes the spill risk assessment process as follows:

1. Identify the spatial extent of the EMBA. This has been completed for this EP as part of the assessment of the existing environment and receptors that are known to occur or may occur within the EMBA are described in **Section 3** and **Appendix D1**;
2. Identify areas of high environmental value (HEV) within the EMBA (HEVs are described in **Section 7.5.6.2**);
3. Identify and then risk assess hot spots. Hotspots are effectively a subset of HEV's and their determination is described in **Section 7.5.6.3**; and
4. Identifies priorities for protection (for consideration of spill response strategies in the OPEP).

7.5.6.1 Spill EMBA

Defining the EMBA by an oil spill is the first step in oil spill risk assessment. For activities where there is the potential for multiple spill scenarios, the spill scenario, or combination of spill scenarios, resulting in the greatest spatial extent of impacts is used to define the overall EMBA for the activity. The EMBA is further described in **Section 3.1.**

7.5.6.2 Areas of High Environmental Value

Santos has predetermined areas of HEV **(Figure 7-2 A** and **B**) along the Western Australian coastline by ranking these areas based on:

+ Protected area status – This is used as an indicator of the biodiversity values contained within that area, where a World Heritage Area, Ramsar Wetland and Marine Protected Area will score higher than areas with no protection assigned; and
+ BIAs of listed threatened species – These are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour, such as breeding, feeding, resting or migration. Each one of these within the predefined areas contributes to the score.

Further input to determine areas of HEV included:

+ Sensitivity of habitats to impact from hydrocarbons in accordance with the guidance document Sensitivity Mapping for Oil Spill Response produced by IPIECA, the International Maritime Organisation and International Association of Oil and Gas Producers;
+ Sensitivities of receptors with respect to hydrocarbon-impact pathways;
+ Status of zones within protected areas (i.e., IUCN (1a) and sanctuary zones compared to IUCN (VI) and multiple use zones);
+ Listed species status and predominant habitat (surface versus subsurface); and

- Social values; i.e., socio-economic and heritage features (e.g., commercial fishing, recreational fishing, amenities, aquaculture).

Tallied scores for each predefined area along the Western Australian coastline were then ranked from 1 to 5, with an assignment of 1 representing areas of the highest environmental value and those with 5 representing the areas of the lowest environmental value.

7.5.6.3 Hot Spots

While the entire EMBA will be considered during risk assessment and spill response planning, it is best practice to concentrate greatest effort and level of detail on those parts of the EMBA that have:

- The greatest intrinsic environmental value – i.e., HEV areas ranked 1-3;
- The highest probability of contact by oil (either floating, entrained or dissolved aromatic); and
- The greatest potential concentration or volume of oil arriving at the area.

These areas are termed 'Hot Spots'. Defining Hot Spots is typically the first step in undertaking detailed spill risk assessment and spill response planning. Hot Spots are a subset of HEV areas that:

- Have the highest probability of contact (at least higher than 5%) above the impact assessment exposure values for surface hydrocarbons and shoreline accumulation based on modelling results; and
- Receive the greatest concentration or volume of oil, either floating or stranded oil, entrained hydrocarbon or dissolved aromatic hydrocarbons above contact exposure values described in **Section 7.5.5**.

7.5.6.4 Priorities for Protection

For the purposes of a spill response preparedness strategy, it is not necessary for all Hot Spots to have detailed planning. For example, wholly submerged Hot Spots may only be contacted by entrained hydrocarbon, and the response would be largely to implement scientific monitoring to determine impact and recovery. Hot Spots with features that are not wholly submerged (i.e., emergent features) should have specific spill response planning conducted. This final determination of 'Priority for Protection' sites, for the oil spill response strategy, is based on the worst-case estimate of surface oil concentration, shoreline loading and minimum contact time at exposure value concentrations. An assessment of each protection priority will be undertaken to determine the most appropriate spill response strategies based on the type of oil and the values of the protection priority area. This can be done through a strategic NEBA approach.

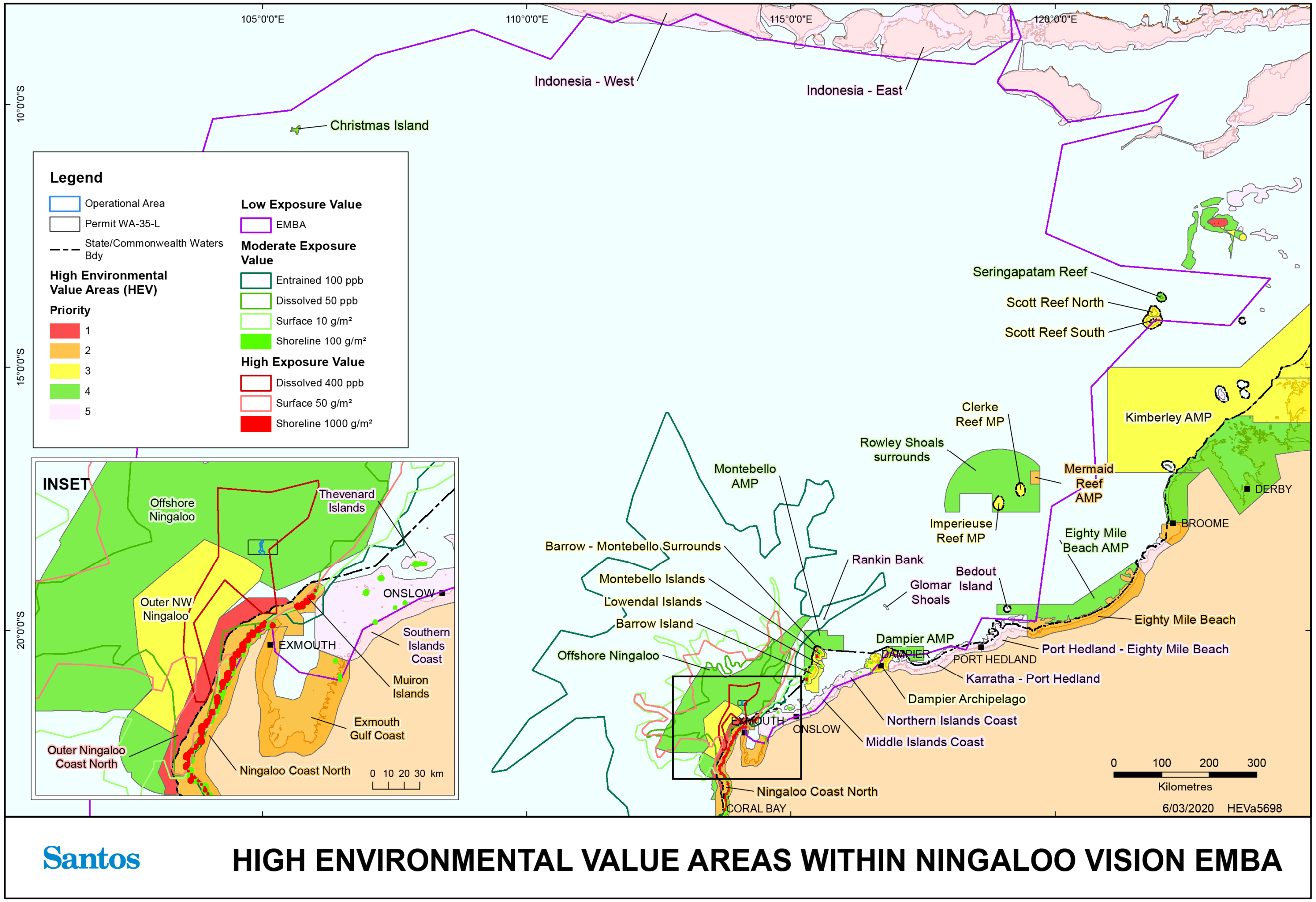

Figure 7-2A: High Environmental Value Areas

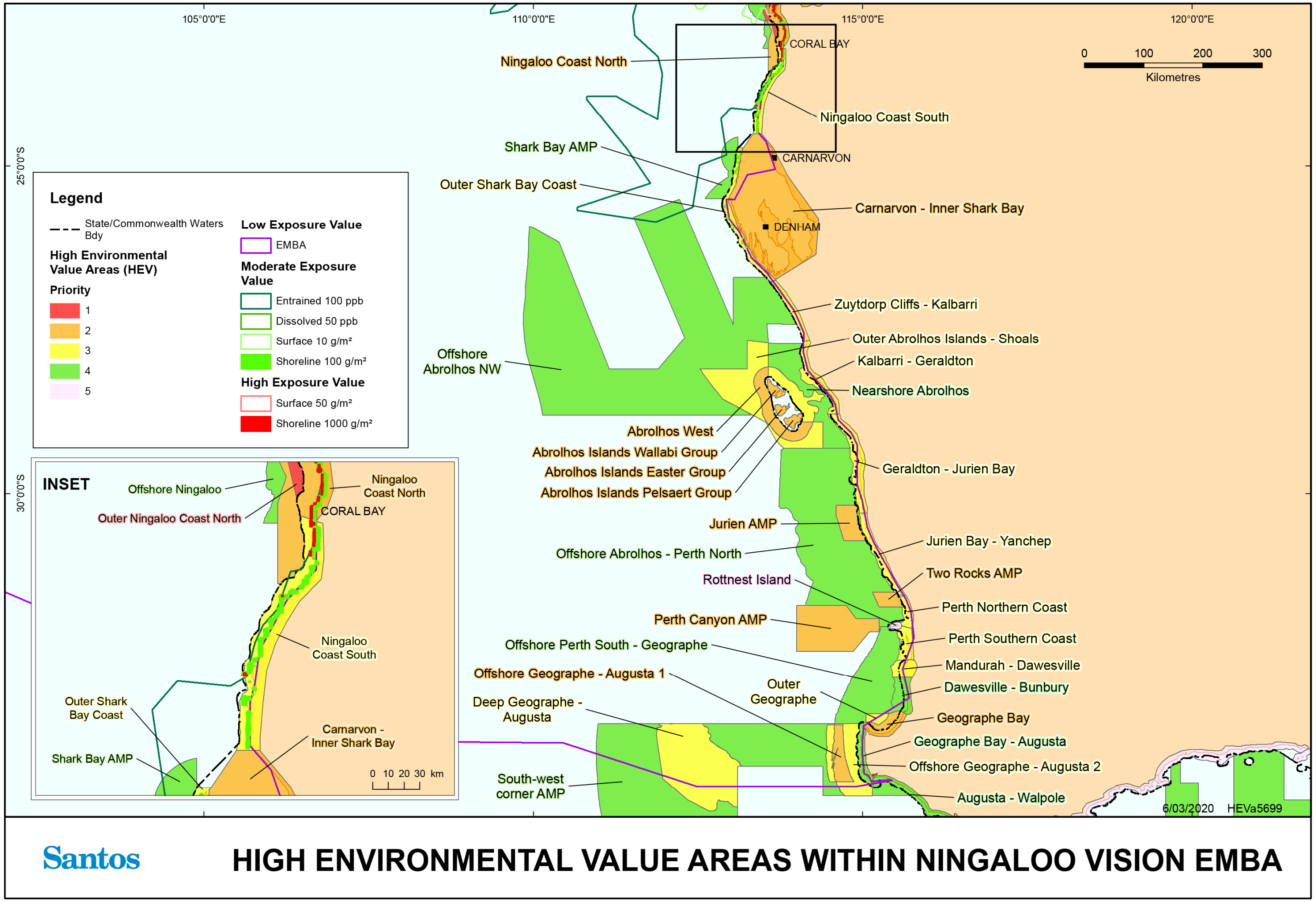

Figure 7-2B: High Environmental Value Areas

7.5.6.5 Potential Hydrocarbon Impact Pathways

To help inform the hydrocarbon spill risk assessment receptors within the EMBA and potential impact pathways have been defined (**Table 7-15**). The potential impact pathways consider physical and chemical pathways. Physical pathways include contact from surface oil, accumulated shoreline oil, or entrained hydrocarbon droplets. Chemical pathways include ingestion, inhalation or contact from any hydrocarbon phase. These are summarised in **Table 7-15** and the information is drawn upon within the hydrocarbon risk assessment for each release scenario (**Sections 7.6 to 7.10**). **Table 7-16** further describes the nature and scale of the hydrocarbon spills associated with NV Operations on marine fauna and socio-economic receptors found within the EMBA at the moderate exposure value.

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Table 7-15: Physical and Chemical Pathways for Hydrocarbon Exposure and Potential Impacts on Receptors

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
Rocky shore	Shoreline loading and attachment may result in thin and sporadic coating of Van Gogh crude blend / HFO / MDO. Degree of oil coating is dependent upon the energy of the shoreline area, the type of the rock formation and continual biodegradation of the Van Gogh crude blend / HFO / MDO.	Impacts to flora (mangroves) and fauna further described below.	Chemical pathway to fauna and flora via adsorption through cellular membranes and soft tissue, ingestion, irritation/burning on contact and inhalation	Impacts to flora (mangroves) and fauna further described below.
Sandy shore	Shoreline loading and water movement may allow Van Gogh crude blend / HFO / MDO residue to filter down into sediments, continue to biodegrade on the surface or remobilise into surf zone. Degree of loading is dependent upon the energy and tidal reach of the shoreline, the type of the sandy shore and continual weathering of the Van Gogh crude blend / HFO / MDO.	Indirect impacts to nesting and foraging habitats for birds and turtles. Direct impacts to infauna.	Chemical pathway to fauna and flora via adsorption through cellular membranes and soft tissue, ingestion, irritation/burning on contact and inhalation	Indirect impacts to nesting and foraging habitats for birds and turtles. Direct impacts (mortality) to infauna through toxic effects and smothering.
Intertidal flats	Shoreline loading and water movement may allow Van Gogh crude blend / HFO / MDO residue to attach to fin substrates, or continue to biodegrade on the surface or remobilise into surf zone. Degree of loading is dependent upon the energy and tidal reach of the shoreline, the type of the substrate	Indirect impacts to foraging habitats for birds and turtles. Direct impacts to infauna.	Chemical pathway to fauna and flora via adsorption through cellular membranes and soft tissue, ingestion, irritation/burning on contact and inhalation	Indirect impacts to foraging habitats for birds. Direct impacts (mortality) to infauna through toxic effects and smothering.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
	and continual weathering of the Van Gogh crude blend / HFO / MDO.			
Mangroves	Coating of root system reducing air and salt exchange. Degree of coating is dependent upon the energy and tidal reach of the shoreline, the type of the substrate and continual weathering of the Van Gogh crude blend / HFO / MDO.	Yellowing of leaves. Defoliation. Increased sensitivity to stressors. Tree death. Reduced growth. Reduced reproductive output. Reduced seed viability.	External contact by oil and adsorption across cellular membranes.	Yellowing of leaves. Defoliation. Increased sensitivity to stressors. Tree death. Reduced growth. Reduced reproductive output. Reduced seed viability. Growth abnormalities.
Algae and seagrass	Coating of leaves/thalli reducing light availability and gas exchange. Degree of coating is dependent upon the energy and tidal reach of the shoreline, the type of the receptor and continual weathering of the Van Gogh crude blend / HFO / MDO.	Bleaching or blackening of leaves. Defoliation. Reduced growth.	External contact by oil and adsorption across cellular membranes.	Mortality. Bleaching or blackening of leaves. Defoliation. Disease. Reduced growth. Reduced reproductive output. Reduced seed or propagule viability.
Hard corals	Coating of polyps, shading resulting in reduction on light availability. Degree of coating is dependent upon the metocean conditions, dilution, if corals are emergent at all and continual weathering of the Van Gogh crude blend / HFO / MDO.	Bleaching. Increased mucous production. Reduced growth.	External contact by oil and adsorption across cellular membranes.	Mortality. Cell damage. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
				Reduced reproductive output. Reduced egg or larval success. Growth abnormalities.
Invertebrates	Coating of adults, eggs and larvae. Reduce mobility and capacity for oxygen exchange. Degree of coating is dependent upon the energy and tidal reach of the shoreline, the type of the receptor and continual weathering of the Van Gogh crude blend / HFO / MDO.	Mortality. Behavioural disruption. Impaired growth.	Ingestion and inhalation. External contact and adsorption across exposed skin and cellular membranes. Uptake of dissolved aromatic hydrocarbons across cellular membranes. Reduced mobility and capacity for oxygen exchange.	Mortality. Cell damage. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Reduced egg or larval success. Growth abnormalities. Behavioural disruption.
Fish	Coating of adults but primarily eggs and larvae - Reduced mobility and capacity for oxygen exchange.	Mortality. Oxygen debt. Starvation. Dehydration. Increased predation. Behavioural disruption.	Ingestion. External contact and adsorption across exposed skin and cellular membranes. Uptake of dissolved aromatic hydrocarbons across cellular membranes (e.g., gills).	Mortality. Cell damage. Flesh taint. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Reduced egg or larval success.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
				Growth abnormalities. Behavioural disruption.
Birds	Coating - Feather matting and damage, reducing insulation, mobility and buoyancy Secondary coating of eggs and hatchlings Degree of coating from shoreline hydrocarbons is dependent upon the energy and tidal reach of the shoreline, the type of the receptor and continual weathering of the Van Gogh crude blend / HFO / MDO.	Feather and skin irritation and damage. It is commonly thought that condensate/diesel does not cause problems to wildlife due to the lack of visible oiling; however, they may suffer toxic effects (DPaW, 2014).	Ingestion (during feeding or preening). External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Growth abnormalities. Behavioural disruption.
Marine reptiles	Coating (particularly hatchlings) – reduced mobility and buoyancy Degree of coating from shoreline hydrocarbons is dependent upon the energy and tidal reach of the shoreline, the type of the receptor and continual weathering of the Van Gogh crude blend / HFO / MDO.	Behavioural disruption. It is commonly thought that condensate/diesel does not cause problems to wildlife due to the lack of visible oiling; however, they may suffer toxic effects (DPaW, 2014).	Inhalation. Ingestion. External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced hatchling success. Reduced reproductive output. Growth abnormalities. Behavioural disruption.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
Marine mammals	Light coating – fur damage and matting, reduced mobility and buoyancy (for applicable species). Coating of feeding apparatus in some species (i.e. baleen whales).	It is commonly thought that condensate/diesel does not cause problems to wildlife due to the lack of visible oiling; however, they may suffer toxic effects (DPaW, 2014).	Inhalation. Ingestion. External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Growth abnormalities. Behavioural disruption.

7.5.6.6 Summary of Potential Impacts

Table 7-16 provides a summary of the potential impacts of hydrocarbon releases to sensitive receptors and values at the moderate exposure values (See **Section 7.5.5**).

Table 7-16: Nature and Scale of Hydrocarbon Spills on Environment and Socio-economic Receptors

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
Marine fauna	
Plankton (including zooplankton; coral larvae and Benthic Invertebrates)	+ There is potential for localised mortality of plankton due to reduced water quality and toxicity. + Plankton utilising surface waters as well as pelagic invertebrates (e.g. jellyfish) could be impacted from surface, entrained or dissolved hydrocarbons. Physical contact of small hydrocarbon droplets may impair plankton mobility, feeding and/or respiration. Plankton could include the eggs and larvae of marine invertebrates (including coral) and fish. The likelihood of this would be determined by the extent and timing of the spill; for example, hard coral spawning occurs primarily in March/April, so there is a heightened potential for impacts to coral eggs and larvae to occur during this period. There is the potential for ingestion of small hydrocarbon droplets or dissolved aromatic hydrocarbons by filter feeding organisms (e.g. jellyfish, salps, zooplankton), which could result in negative impact to some species. + Potential for impacts due to physical contact with entrained hydrocarbon is greater for Van Gogh crude blend and HFO compared to MDO, given the more persistent nature of crude / HFO, however, toxic impacts from aromatic hydrocarbons is a more significant source of impact from an MDO release compared to crude / HFO. Further, a greater proportion of plankton biomass in the affected area will be exposed to entrained hydrocarbons in the event of a subsea release of crude (well leak or subsea system) compare to a surface release. + Benthic invertebrates, particularly those using intertidal habitats of the Ningaloo Coast and Barrow Island and Montebello Islands could be contacted at moderate exposure values + The abundance and diversity of epi-benthic invertebrates is likely to be highest in shallow subtidal habitats such as hard corals, seagrasses, macroalgae. Benthic invertebrates may be impacted by oiling interfering with feeding and respiratory structures. There is also the potential for hydrocarbon to be ingested by filter feeding invertebrates such as molluscs and sponges; bivalves could potentially bioaccumulate hydrocarbons. As a more persistent hydrocarbon, potential impacts from physical smothering are likely to be higher for a crude / HFO release compared to an MDO release, depending on the volumes. Further to this, recovery time of intertidal habitats may be longer for a crude / HFO release compared to MDO, as greater proportion of the invertebrate population may be exposed to entrained hydrocarbons in the event of a crude (particularly subsea release) / HFO release compared to MDO.

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values

Marine mammals	+ Marine mammals are at risk of direct contact with MDO, HFO and Van Gogh crude blend due to chance of surfacing within the slick. Effects include irritation of eyes/mouth and potential illness. In addition, surfacing in a slick may lead to accidental ingestion of hydrocarbons or result in the coating of sensitive epidermal surfaces. There is an increased potential for volatile hydrocarbons to be inhaled if marine mammals were to surface within a surface slick especially if close to the release sites where the hydrocarbon would be relatively fresh (i.e. have a greater concentration of volatile MAHs such as BTEX chemicals).
	+ Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness may occur should marine mammals contact dissolved and entrained hydrocarbons in the water column. Marine mammals could potentially ingest entrained hydrocarbon when feeding in open water.
	+ Sixteen marine mammals were identified by the EPBC Protected Matters search for the EMBA (**Section 3.2.4**). BIAs overlapping the EMBA include:
	  + Humpback whale - migration (north and south) and resting
	  + Pygmy blue whale – foraging, migration and distribution
	  + Sperm whale- foraging
	  + Dugong - breeding, foraging (high density seagrass beds), nursing and calving
	  + Southern Right Whale - seasonal calving habitat
	  + Australian Sea-lion - foraging
	Of these species the humpback whale (migration and resting), pygmy blue (distribution, migration and foraging), dugongs and Australian sea-lion BIAs are closer to the operational area and are therefore likely to be exposed to greater concentrations of hydrocarbons (at or above the moderate exposure values).
	+ Surface and entrained MDO, HFO and Van Gogh crude blend at moderate exposure concentrations could occur within the humpback whale migration BIA in the event of an unplanned release. Should a hydrocarbon spill occur within migration season (June to October) risk of impact to humpback whales is greater. A greater proportion of the migrating population may be contacted by surface or entrained hydrocarbons, and if individuals actively avoid the spill (or spill response activities) migration pathways may be disrupted.
	+ Dugongs may be indirectly impacted via habitat loss due to reduction in seagrass due to from contact with entrained hydrocarbons. Direct impacts to dugongs could occur through foraging or ingesting seagrass coated with hydrocarbon. Additionally, where surface slicks are expected to extend into shallower coastal waters, impacts from contact with surface hydrocarbons may also occur as they surface to breathe.

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
	+ The Australian sea-lion may be affected at moderate exposure values; however, are unlikely to occur within the spill trajectory for surface hydrocarbons at moderate exposure concentrations, and no significant breeding locations (e.g. Abrolhos Islands) are expected to be contacted by significant volumes of accumulated hydrocarbons at moderate exposure values. Individuals may encounter entrained or dissolved aromatic hydrocarbons, which is unlikely to occur to a large proportion of the overall population.
Marine reptiles	+ Marine reptiles are at risk of direct contact with hydrocarbons due to chance of surfacing within slick, effects include irritation of eyes/mouth and potential illness. Entrained and dissolved hydrocarbons may lead to lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness. + The greatest potential for impact to turtles or seasnakes is likely to be in feeding areas where surface and/or entrained hydrocarbons have contacted shallow water foraging habitats (e.g. seagrass, hard coral and macroalgae) or, in the case of turtles, at any turtle nesting beaches that have been contacted by stranded surface MDO, HFO or Van Gogh crude blend. + Green, hawksbill, flatback and loggerhead turtles utilise shallow waters and nesting beaches along coastlines of the Ningaloo Coast, Barrow Island, Muiron Islands, Montebello Islands and Thevenard Island, all of which may be contacted at moderate exposure values. The risk at these nesting beaches is for hydrocarbons to contact adult females during nesting season or turtle hatchlings 6-8 weeks following nesting or to accumulate on the shorelines. Hydrocarbons may cause irritation to turtles' sensitive organs such as eyes. In terms of entrained hydrocarbons within shallow coastal waters turtles may be sensitive since they feed in shallow water coral and macroalgae habitats and may ingest entrained MDO, HFO or Van Gogh crude blend as well as potentially being contacted on external surfaces. + BIAs for the flatback turtle, green turtle, hawksbill turtle and loggerhead turtle all are within the extent of the moderate exposure value for entrained hydrocarbons from the worst case credible spill, which is the largest area reaching moderate exposure value.
Seabirds and shorebirds	+ Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness may occur should seabirds and shorebirds be exposed to MDO, HFO and Van Gogh crude at moderate exposure values, however it is commonly thought that MDO does not cause problems for wildlife due to the lack of visible oiling however may be toxic (WAOWRP, 2014). + Seabirds are at risk of contacting surface, entrained or dissolved MDO, HFO and Van Gogh crude blend while diving and foraging. + Shorebirds may encounter MDO, HFO and Van Gogh crude blend accumulating on shorelines at feeding, roosting and breeding sites. + Foraging seabirds may continue to forage within slicks as most fish survive beneath floating slicks. Smothering of oil on seabird during foraging can lead to reduced water proofing of feathers and ingestion while preening. In addition, hydrocarbons can erode feathers causing chemical damage to the feather structure that subsequently affects ability to thermoregulate and maintain buoyancy on water. + Seabirds may ingest surface and/or entrained hydrocarbon when feeding in affected offshore waters or coastal waters, however it is unlikely that significant quantities of oil would be ingested. Coating of feathers on birds diving into entrained hydrocarbon is a possibility

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
	although the concentration of hydrocarbon is unlikely to lead to significant oiling since neither MDO, HFO nor Van Gogh crude blend are particularly sticky when compared to other hydrocarbons. The risk of impact is greater should a release within the chick rearing period, where adults forage closer to breeding colonies. EPBC listed seabird species (see Section 3.2.4) have BIAs for breeding or foraging that overlap the are potential impacted by a hydrocarbon release. Potential impacts to these species would be greater should a release occur within the periods of peak habitat use. + The risk to shorebirds and coastal species would depend upon where hydrocarbon accumulates; accumulation near nesting colonies or areas supporting feeding aggregations (i.e. sand/mud flats) would result in greatest impacts.
Fish and sharks	+ The most likely impact of dissolved aromatic hydrocarbons and/or entrained hydrocarbon droplets on fish is through the pathways of ingestion or the coating of gill structures. This could lead to respiratory problems or accumulation of hydrocarbons in tissues. In the worst instance this could lead to mortality, or sub-lethal stress. Although relatively low entrainment of hydrocarbons in the water column was predicted for all scenarios modelled, entrainment is expected to be greater subsea crude releases, with greater potential for impact to fish. Further, very low levels of dissolved aromatic hydrocarbons are expected for all Van Gogh crude blend release scenarios, and therefore potential impacts form toxicity is very low for these scenarios. + There is potential for localised mortality of fish eggs and larva due to reduced water quality and toxicity. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest and therefore demersal fish communities are not expected to be impacted. + While fish and sharks do not generally break the sea surface, individuals may feed at the surface for a short period. Hydrocarbon is expected to quickly disperse and evaporate (modelling results indicate a significant proportion of the hydrocarbon mass from the water surface evaporates within 24 hours at moderate wind speeds for all hydrocarbon types), the probability of prolonged exposure to a surface slick by fish and shark species is low. + A whale shark foraging BIA is in close proximity to the operational area and a BIA for aggregation events off the Ningaloo coast, is approximately 25 km from the operational area and within the moderate exposure value area. Whale sharks are oceanic, but also come into shallower, coastal waters to feeds in surface waters which often coincide with specific productivity events that are a focus of feeding for the animals. It is therefore possible that surface and/or entrained hydrocarbon and/or dissolved aromatic hydrocarbon could come in contact with, or be ingested by, whale sharks migrating or aggregating in the area at the time of release.
Shoreline Habitats	
Shoreline Habitats	+ There is a low probability of volumes of MDO and HFO to accumulate on shorelines at Ningaloo Coast. A number of shorelines that could be contacted by Van Gogh crude blend are presented in Section 7.6.2, 7.7.2 and 7.8.2.

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
	+ The Ningaloo Coast is important for green turtles, and to a lesser extent hawksbills turtles, while Muiron Islands has a regionally important nesting site for loggerhead turtles. Barrow Island supports regionally important nesting rookeries of flatback turtles and Thevenard Island has notable green turtle nesting. Impacts to turtles could occur from surface hydrocarbons if oil accumulated on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. + Since Van Gogh crude blend and HFO is more persistent than MDO, weathering of Van Gogh crude blend and HFO will take longer than potentially exposing a greater proportion of a nesting turtle population to adverse effects of stranded hydrocarbons, depending on the volumes released.
Intertidal/subtidal habitats	
Hard corals	+ In the worst instance direct contact to intertidal corals by surface and/or entrained hydrocarbon could lead to smothering and reduced capacity for photosynthesis by zooxanthellae; or chemical toxicity across cellular structures leading to coral bleaching or colony death. Direct contact by dissolved aromatic hydrocarbons can cause lethal and sub-lethal effects in corals, depending on the time and duration of exposure of the concentrations, with sub-lethal effects including decreased growth rates and reduced reproductive success (IPIECA, 1992). In the worst-case instance, irreversible tissue necrosis and death could occur. While acute impacts to hard corals from oil spills are possible, they are most likely at high oil concentrations (as opposed to chronic impacts which can occur at relatively low concentrations over long periods) (NOAA, 2010a). + Potential exists for hard coral to be contacted by entrained hydrocarbons moderate exposure values at a number of locations, notably the Ningaloo Coastline, Dampier Archipelago, Muiron island and Barrow Island. + Given that MDO has a relatively low persistence and is not considered a sticky oil, hard coral exposure to a spill of the magnitude is expected to be short term. This is particularly the case in areas where wave action is conducive to dispersing oil (e.g. fringing coral reef with breaking waves or rocky shorelines/platform with hard corals). Coral reef habitats exposed to entrained Van Gogh crude and HFO, being more persistent hydrocarbons would be expected to take longer (within weeks to months of return to normal water quality conditions). Several studies have indicated that rapid recovery rates may occur even in cases of heavy oiling (Burns et al., 1993; Dean et al., 1998). Further, tidal cycles/wave action is expected to prevent long term coating of intertidal corals by surface oil. + The timing of an oil spill event in relation to other environmental stresses, such as ambient temperature, or reproductive stage could also have significance in that corals are likely to be more sensitive to oil spill events at times of physiological stress. Coral spawning at Ningaloo Coast peaks during March/April with a minor peak in October and spills during this period would likely have greatest potential for impact to hard corals and their larvae.

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
Macroalgae and seagrass	+ As with hard corals, intertidal and subtidal macroalgae and seagrass could be impacted by surface and/or entrained MDO, HFO and Van Gogh crude blend. Impacts could include reduced capability for photosynthesis if the seagrass or macroalgae were smothered; or toxic effects could occur from contact with the hydrocarbon. Areas of seagrass that could be impacted based on moderate exposure values being reached include coastal waters off the Ningaloo Coast as well as outer Shark Bay. Since Van Gogh crude blend and HFO is more persistent than MDO, contact from crude and HFO may require a longer recovery time compared to MDO, depending on the volumes released. + Impacts to seagrass may present secondary impacts to species reliant on the habitat such as Dugongs.
Mangroves	+ Mangrove root systems (including pneumatophores) are sensitive to physical oiling from surface hydrocarbons. Impacts to mangroves include yellowing of leaves, defoliation, reduced reproductive output and success, mutation and increased sensitivity to other stresses (NOAA, 2010b). There is the potential for stands of mangroves at a number of shorelines, notably along the Ningaloo Coastline (e.g. at Mangrove Bay and at Yardie Creek) to be contacted at moderate exposure values. Since Van Gogh crude blend and HFO is more persistent than MDO, contact from crude and HFO may require a longer recovery time compared to MDO, depending on the volumes released.
Intertidal mud/sandflats	+ Intertidal mud/sandflats contacted at moderate exposure values have the potential to interfere with infaunal organisms (crabs, molluscs) etc. either by modifying the habitat (blocking burrowing holes and binding sediments) or smothering feeding/respiratory/locomotory structures of these organisms. + Secondary impacts may occur to fauna such as shorebirds which utilise the mud and sandflats for feeding should they ingest contaminated invertebrates or preening of feathers in the area. + Important intertidal mud/sand flat areas along the Ningaloo Coastline are associated with mangrove areas (e.g. Mangrove Bay), which could be contacted at the moderate exposure values. Since Van Gogh crude blend and HFO is more persistent than MDO, contact from crude may require a longer recovery time compared to MDO, depending on the volumes released, which is expected to be short in duration.
Intertidal rocky reefs	+ Contact to intertidal rocky reef areas could occur from surface entrained or dissolved hydrocarbons. These habitats often support attached invertebrates (e.g. molluscs, hard and soft corals) and support mobile invertebrates that shelter in crevices (e.g. crabs), which could potentially be exposed to lethal or sub-lethal toxicity impacts. Since Van Gogh crude blend and HFO is more persistent than MDO, contact from crude may require a longer recovery time compared to MDO, depending on the volumes released, which is expected to be short in duration.
Socio-economic	

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
Fisheries	+ Several commonwealth and state fisheries are found within the EMBA. + Hydrocarbons in the water column can have toxic effects on fish (as outlined above) and cause 'tainting' reducing catch rates and rendering fish unsafe for consumption. + Exclusion zones surrounding a spill can directly impact fisheries by restricting access for fishermen. + Hydrocarbon releases have the potential to lead to temporary financial losses due to impact to fish. In the worst instance, a spill could lead to loss of (or loss of function of) coastal intertidal habitat (e.g. seagrass meadows, mangrove communities, intertidal mudflats), which provide nursery habitat for fishery species (e.g. fish and crustaceans). Hydrocarbon contact on fish/invertebrate gill structures, the ingestion of hydrocarbon by target species and the potential for entrained hydrocarbon to interfere with the development of fish eggs and larvae could also potentially impact fisheries for a period after the spill is contained.
Tourism	+ There is the potential for surface, entrained and/or dissolved aromatic hydrocarbon to temporarily disrupt tourism activities which rely on the presence of marine fauna and/or the use of vessels (e.g. snorkelling/scuba diving, whale/whale shark watching/swimming and recreational fishing) via displacement from an exclusion zone or a reduction in fauna abundance due to avoidance of the area. + Impacts to recreational fishing may also occur due to impacts to fish as described for Fisheries above. + Visible oiling from accumulated hydrocarbons may close beaches along the Ningaloo Coast, an important tourist location, where concentrations of accumulated hydrocarbons are greatest.
Shipping	+ A number of shipping fairways intersect the EMBA and moderate exposure value area. + In the event of a hydrocarbon spill shipping activities may be impacted by exclusion zones surrounding a spill. Exclusion zones could reduce access for shipping vessels for the duration of the response undertaken for spill clean-up (if applicable) meaning vessels may have to take detours leading to potential delays and increased costs.
Defence	+ Military exercise areas are located at Exmouth and Derby associated with the RAAF Base Learmonth and Curtin respectively. These training zones overlap the EMBA and moderate exposure value area. However, they have been for aerial training are unlikely to be impacted by a hydrocarbon spill.
Shipwrecks	+ There are shipwrecks within the EMBA and moderate exposure value area. + Surface hydrocarbons will have no impact on shipwrecks. + Notable shipwrecks include three historic shipwrecks at Pt Cloates along the Ningaloo Coast (Fin, Perth and Zvir) and one historic shipwreck at North West Cape (Fairy Queen). It is unlikely that contact would have any lasting impact on these sites apart from a possible temporary reduction in aesthetic value for a period.

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
Indigenous	+ Marine resource use by indigenous people is generally restricted to coastal waters. Fishing, hunting and the maintenance of maritime culture and heritage through ritual, stories and traditional knowledge continue as important uses of the nearshore region and adjacent areas. + Indigenous users may be impacted by surface hydrocarbons, exclusion zones around spill sites during spill response and fishing and hunting stocks may be impacted by entrained and dissolved hydrocarbons. + Aboriginal artefacts, scatter and rock shelter are contained on Barrow and Montebello islands.
Existing oil and gas activity	+ A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A surface or subsea hydrocarbon spill has the potential to disrupt activity with associated economic impact. + Exclusion zones surrounding spills will reduce access, potentially resulting in delays to work schedules with possible subsequent financial implications. In particular, Chevron's Gorgon and WA Oil operations on Barrow Island may be impacted in the event of an unplanned spill event through exclusion or access restrictions in the event of spill response and clean-up activities (if applicable).
Protected Areas	
Protected Areas	The EMBA overlaps several KEFs (**Section 3.2.3**). The following KEFs could be contacted at the moderate exposure value: + Continental Slope Demersal Fish Communities – the eggs/larvae fish within these communities could be impacted from direct contact with entrained hydrocarbons. + Commonwealth waters adjacent to the Ningaloo Marine reserve + Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula - the assemblages of epibenthic species of this KEF are unlikely to be impacted by a hydrocarbon release. Aggregations of pelagic species, including whale sharks, manta rays, humpback whales, sharks, large predatory fish and seabirds, may be impacted by entrained and surface hydrocarbons as described above; + Ancient coastline at 125 m depth contour – this feature may support enhanced productivity and may attract opportunistic feeding by larger marine life including humpback whales, whale sharks and large pelagic fish, these species could be impacted by entrained or surface hydrocarbons; + Exmouth Plateau – this feature may support enhanced productivity supporting pelagic fish species and potentially sperm whales. Pelagic fish and sperm whales may be contacted by entrained hydrocarbons as described above. Sediments supporting a high

Receptor	Impacts of hydrocarbon releases on sensitive receptors at the moderate exposure values
	diversity of epi and infauna are unlikely to be impacted given the water depths (>300 m within the operational area) in the KEF and the low levels of entrainment predicted.

Commonwealth and State Marine Protected Areas	+ Protected areas within the moderate hydrocarbon exposure value for entrained hydrocarbons (which covers the largest area compared with other hydrocarbon phases) are summarised below. For full descriptions of these areas refer to **Section 3.2.3** and **Appendix D1**.
	+ National and World Heritage Listed Areas:
	  + Dampier Archipelago (including Burrup Peninsula)
	  + Ningaloo WHA
	  + Shark Bay WHA
	+ Australian Marine Parks
	  + Montebello AMP
	  + Gascoyne AMP
	  + Abrolhos AMP
	  + Ningaloo AMP
	  + Carnarvon Canyon AMP
	+ State Marine Parks and Marine Management Areas:
	  + Muiron Islands MMA
	  + Montebello/Barrow Islands Marine Conservation Reserve
	  + Ningaloo Marine Park
	  + Shark Bay Marine Park
	  + Barrow Island MMA and Marine Park
	These protected areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described above therefore have an impact on the values of these reserves which could have flow-on effects to tourism revenue of coastal communities that provide access to these protected areas. The areas listed above may also support nursery/feeding/aggregation areas for fisheries species and therefore may assist in maintaining healthy fish stocks and commercial/recreational fisheries.

7.6 Subsea Release of Hydrocarbon from a Production Well to the Marine Environment

7.6.1 Description of Event

Events

The following scenarios could potentially result in a Van Gogh crude blend release from a production well leak:

No.	Scenario	Volume Maximum credible volume
1	Subsea release of Van Gogh crude blend from a production well as a result of an external impact, such as anchor/chain drag.	10,236 m^3 over 100 days
2	Subsea release of Van Gogh crude blend from a production well as a result of an internal influence	114 m^3 over 465 days (365 days to detect, plus 100 days to control)

1. Subsea release of Van Gogh crude blend from a production well as a result of an external impact, such as anchor/chain drag.

During extreme cyclone conditions it is possible that a mobile offshore drilling unit (MODU) working for an operator of an adjacent field breaks loose from its mooring and drifts over the location of the Van Gogh, Coniston and Novara subsea wells.

If the drifting MODU drags an anchor and / or anchor chains over the seabed then it is possible that they latch on to or wrap over a subsea tree of a production well connected to the NV FPSO, thus imparting a substantial force on the wellhead, tree and completion.

If a MODU chain or anchor were to apply sufficient bending force on the wellhead, the wellhead could bend at the soft mudline until it is aligned with the direction of the pulling force. Should the force implied by the drifting MODU continue to increase above the yield strength of the chain, the chain will fail. That is, the anchor chains on the MODUs operating in the vicinity of the operational area do not have strength required to separate the wellhead and the subsea tree off the well. It follows that since the wellhead and subsea tree remain in place, an uncontrolled release of well fluids through a full-bore blowout is not a credible scenario.

The worst-case failure mechanism as a result of this event would be stress cracking at the bend point combined with failure of a primary barrier. The maximum credible release of hydrocarbon subsea is therefore 10,236 m^3 (based on the maximum flowrate through the leak hole) over 100 days.

2. Subsea release of Van Gogh crude blend from a production well as a result of an internal influence

This scenario requires superposition of failures of multiple barriers – production packer, production casing and/or cement bonds.

Based on industry experience and published research, the most plausible and a conservative leak pathway/scenario is determined to be:

a) The cement bond outside of the 9-5/8” casing degrades over time as a result of thermal cycling of wells during production, and a micro-annulus is formed between the exterior of the 9-5/8” casing and the cement sheath.

b) This micro-annulus is 1mm in width, extends homogenously around the entire circumference of the casing, and extends from the top of reservoir along the entire length of the 9-5/8” cement job. This results in a direct leak pathway

	between the reservoir and the 9-5/8" x 13-3/8" annulus – a failure of the primary barrier. c) The secondary barrier fails through either of the following failure modes: **Scenario 1:** As a result of corrosion (or some other failure mechanism like anchor collision) a 0.55" diameter hole develops in the 13-3/8" casing or HPWHH near mudline; or **Scenario 2:** A micro-annulus forms in the 13-3/8" cement, which is 1mm in width. It extends homogenously around the entire circumference of the casing, and extends from the 13-3/8" shoe along the entire length of the 13-3/8" cement job to mudline. d) Reservoir fluid (assumed in a worst case to be 100% oil with solution gas – as would occur on Day 1) flows through the two failed barriers where it discharges through a continuous leak path to seabed. The worst case discharge rate from internal failure of multiple barriers has been determined to be 1.54 stb/d (0.245 m^3/d) of Van Gogh crude blend. Given the low flow rates, there would be no meaningful depletion effects, and this leak would continue at the initial rate until identified and fixed. For an estimate of leak duration, this type of leak would not be detected by the control system or annual integrity testing and would only be detected by annual ROV surveys or because of investigation triggered by continuous visible oil sheen on the sea surface. The leak could occur for up to 365 days without detection, and given that remediation/intervention is assessed to take approximately 100 days, this leak could occur for approximately 465 days.
Extent	Stochastic modelling determined that the hydrocarbon extent based on moderate exposure values (**Section 7.5.5**) is: + Surface oil may occur out to 15 km from the release location. + Entrained hydrocarbon may occur out to 250 km from the release location. + Shoreline accumulation may occur a number or receptors, the furthest being Outer Shark Bay Coast, approximately 400 km from the release location. + Dissolved hydrocarbons are highly local to the release.
Duration	Upon detection of a release from an external influence on a well, a 100 day release duration is based on duration to control the well. The release period is based on a conservative rig mobilisation and relief well drilling schedule. An undetected leak from internal influence could be undetected for up to 365 days and take an additional 100 days for remediation/intervention..

7.6.2 Nature and Scale of Environmental Impacts

Hydrocarbon spills will cause a decline in water quality and may cause chemical (e.g. toxic) and physical impacts to marine species (e.g. coating of emergent habitats, oiling of wildlife at sea surface). The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (i.e. extent, duration) and sensitivity of the receptor.

<u>Potential receptors: Shallow benthic, intertidal and shoreline habitats; plankton; invertebrates; fish; marine mammals; marine reptiles; birds (seabirds and shorebirds); fisheries; oil and gas industry; tourism; KEFs; and State and Commonwealth marine reserves and Australian Marine Parks.</u>

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are further described in **Table 7-16**.

7.6.2.1 Hydrocarbon Weathering Behaviour

Weathering tests using the Mackay Nadeau Steelman apparatus were performed on a Van Gogh crude blend oil in 2018 by Intertek (Intertek, 2018) using climatic parameters of 20 km/h wind, 29°C water temperature and 22°C wind speed. The findings and conclusions of the testing are as follows:

+ Unweathered crude had little or no volatile components.
+ Overall, there is little change over the weathering period (72 hours) under the test conditions.
+ The total loss of volume of the Van Gogh crude blend oil was calculated at 24% at 72 hours increasing from 18% loss in the first 8 hours.
+ The Van Gogh crude blend oil further degraded and became heavier, more viscous, contained more wax content and less volatiles as it weathered.
+ Despite an increase in wax content overtime, low pour points are likely to limit the ability of the Van Gogh crude blend oil to form unstable emulsions over time in the event of a spill
+ The net result of weathering the Van Gogh crude blend oil is effectively losing the remaining volatile fraction of the oil and leaving a further degraded, waxier and heavier crude oil in any spill incident.

Figure 7-3 shows that the rate of weathering is rapid up to 18% loss at the 8th hour and the rate of weathering declines significantly thereafter. A further loss of only 6% was measured from 8 hours to 72 hours (Intertek, 2018).

Weathering of the Van Gogh crude blend oil will have little effect on the composition in the event of a spill. The already degraded oil gets heavier with an increase in wax content (Intertek, 2018). The composition in terms of saturate, aromatics, resin and asphaltene contents generally remains unchanged. The net result of weathering the Van Gogh crude blend oil is effectively the loss of the remaining volatile fraction of the oil resulting in a further degraded, waxier and heavier crude oil in any spill incident (Intertek, 2018).

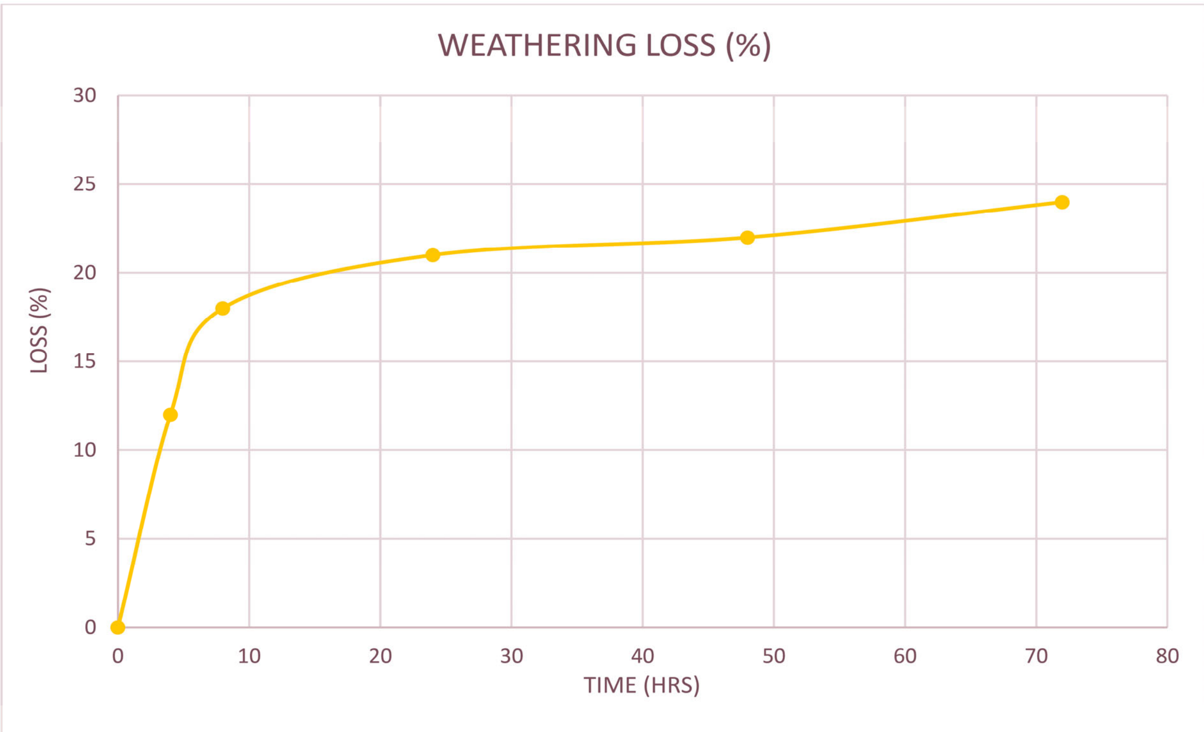

Figure 7-3: A summary of the weathering (loss) for the Van Gogh crude blend Oil in winter test conditions over 72 hours (Intertek, 2018)

GHD (2019) modelled weathering of the SINTEF Linerle at wind speeds of 1, 5 and 10 m/s. moderate winds (5 m/s), 80% of the initial surface slick is predicted to remain after 120 hours. However, with high winds (10 m/s), significantly higher rates of dispersion are predicted, with approximately 65% of the released oil dispersed into the water column after 24 hours, and approximately 80-85% after 48-120 hours (GHD, 2019) (**Figure 7-4**).

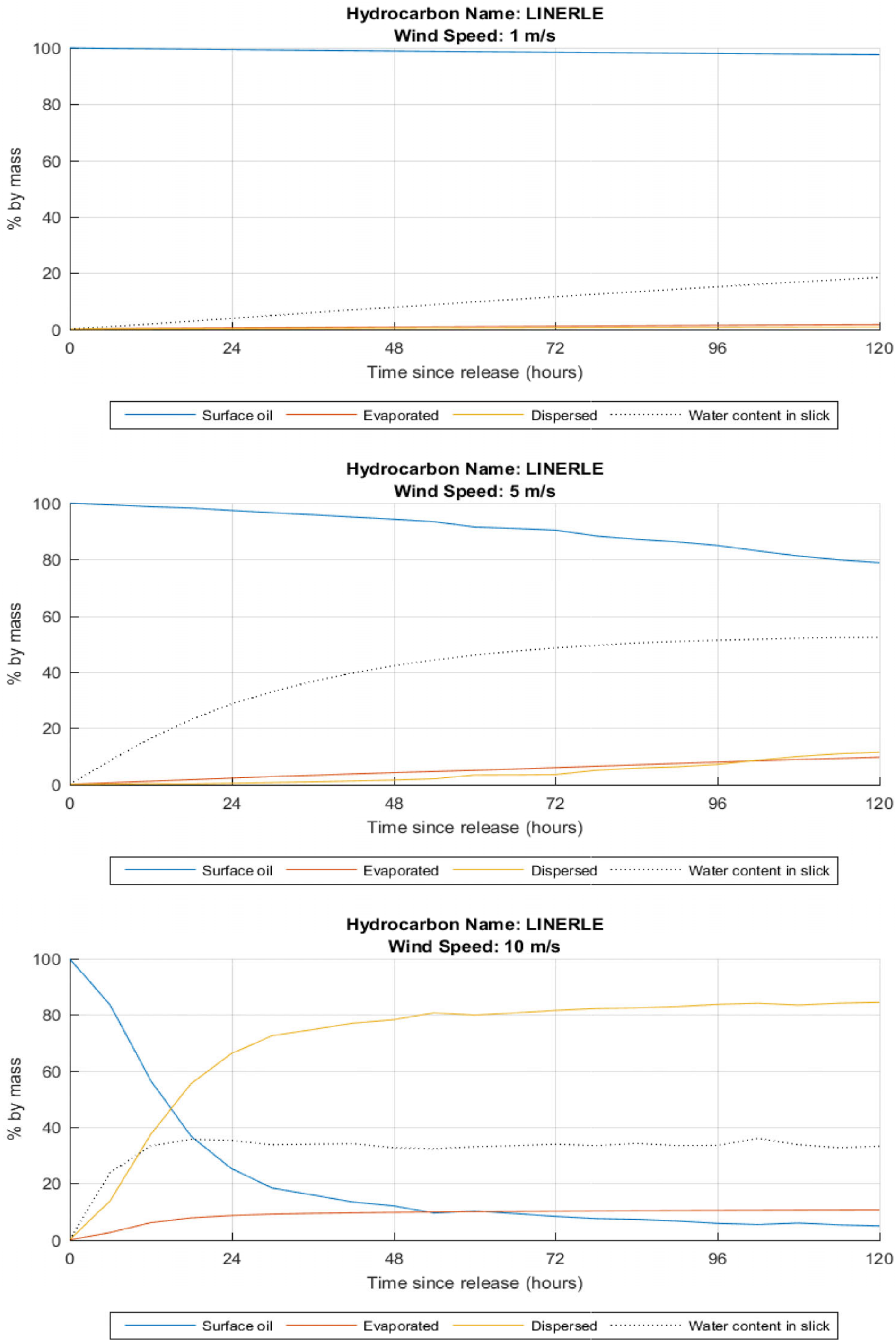

Figure 7-4: Simulated weathering of the SINTEF Linerle hydrocarbon for constant wind speeds of 1 m/s (top), 5 m/s (middle) and 10 m/s (bottom) (GHD, 2019)

7.6.2.2 Spill Modelling Results

To determine the spatial extent of impacts from a potential subsea release of Van Gogh crude blend from a well leak and the dispersion characteristics over time, modelling was completed by GHD (GHD, 2019). A volume of 10,236 m^3 released subsea over 100 days was modelled based on it being the maximum credible volume from a leak event (as described in **Section 7.6.1**).

Modelling results have been provided for each of the four hydrocarbon fates: shoreline accumulation; surface; dissolved and entrained.

The modelling results are presented for the fate of hydrocarbon at the exposure values defined in **Section 7.5.5.** has been provided for the purposes of risk evaluation, displaying the following parameters:

+ Minimum time to contact from moderate and high exposure value;
+ Maximum hydrocarbon concentration from high exposure value;
+ Maximum hydrocarbon accumulation on shoreline from moderate and high exposure value; and
+ Length of shoreline oiled.

Further parameters required to inform spill response strategies are described further in the NV Operations OPEP (TV-00-RI-00003.02).

<u>Surface Oil</u>

Low

Stochastic modelling determined that surface oil at concentrations equal to or greater than 1 g/m^2 could extend up to 400 km from the release location. HEVs with the potential to be contacted at the low exposure value are:

+ Barrow Island;
+ Barrow-Montebello Surrounds;
+ Southern Islands Coast;
+ Muiron Islands;
+ Exmouth Gulf Coast;
+ Ningaloo Coast North;
+ Montebello AMP;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Moderate and High

Stochastic modelling determined that surface oil at moderate exposure value of 10 g/m^2 may occur out to 15 km from the release location. Surface oil at the high exposure value of 50 g/m^2 is localised to the release location. HEVs with the potential to be contacted at the moderate exposure value are:

+ Offshore Ningaloo; and
+ Outer NW Ningaloo.

<u>Dissolved Aromatic Hydrocarbons</u>

Stochastic modelling determined that dissolved aromatic hydrocarbons at the low exposure value of 10 ppb and above were not exceeded.

Entrained hydrocarbon

Low

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 10 ppb may occur out to 1,300 km from the release location.

Moderate and High

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 100 ppb may occur out to 250 km from the release location. At the moderate exposure value of 100 ppb there is greater than 1% probability of entrained hydrocarbon reaching four HEVs: Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo. No HEVs are contacted at the high exposure value.

Shoreline Accumulation

Low

Shoreline accumulation above the low exposure value may occur at 28 HEVs with the furthest from the release location being Augusta - Walpole, approximately 1,500 km from release location. Shoreline accumulation may also occur on the shores of Indonesia.

Moderate

Shoreline accumulation above the moderate exposure value of 100 g/m^2 may occur at 13 HEVs:

+ Dampier Archipelago;
+ Northern Islands Coast;
+ Montebello Islands;
+ Lowendal Islands;
+ Barrow Island;
+ Middle Islands Coast;
+ Thevenard Islands;
+ Southern Islands Coast;
+ Muiron Islands;
+ Exmouth Gulf Coast;
+ Ningaloo Coast North;
+ Ningaloo Coast South; and
+ Outer Shark Bay Coast.

The furthest being Outer Shark Bay Coast, approximately 400 km from the release location.

High

Shoreline accumulation above the high exposure value of 1,000 g/m^2 may occur at four HEVs: Montebello Islands, Barrow Island, Muiron Islands, Ningaloo Coast North and Ningaloo Coast South.

Table 7-17: Summary of Hydrocarbon Contact with Receptors: 10,236 m^3 Subsea Crude Release

Receptor	Receptor Type	Minimum time to contact (days)							Maximum hydrocarbon concentration							Maximum oil ashore (tonnes)	Maximum length of oiled shoreline (km)
		Moderate exposure values				High exposure values			Moderate exposure values				High exposure values				
		Shoreline accumulation 100 g/m^2	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50 g/m^2)	Shoreline accumulation (100 gm^2)	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50 g/m^2)	Shoreline accumulation (100 g/m^2)	Shoreline accumulation (100 g/m^2)
Dampier Archipelago	Emergent	23	NC	NC	NC	NC	NC	NC	130	NC	NC	NC	NC	NC	NC	3	13
Northern Islands Coast	Emergent	39	NC	NC	NC	NC	NC	NC	132	NC	NC	NC	NC	NC	NC	2	9
Montebello Islands	Emergent	14	NC	NC	NC	NC	15	NC	1,025	NC	NC	NC	NC	1,283	NC	16	21
Lowendal Islands	Emergent	38	NC	NC	NC	NC	NC	NC	132	NC	NC	NC	NC	NC	NC	1	4
Barrow Island	Emergent	11	NC	NC	NC	NC	15	NC	1,223	NC	NC	NC	NC	1,612	NC	31	38
Middle Islands Coast	Emergent	13	NC	NC	NC	NC	NC	NC	134	NC	NC	NC	NC	NC	NC	1	4
Thevenard Islands	Emergent	9	NC	NC	NC	NC	NC	NC	265	NC	NC	NC	NC	NC	NC	3	9

Southern Islands Coast	Emergent	7	NC	NC	46	NC	NC	NC	687	NC	NC	110	NC	NC	NC	9	13
Muiron Islands	Emergent	4	NC	NC	56	NC	4	NC	5,454	NC	NC	104	NC	5,328	NC	86	17
Exmouth Gulf Coast	Emergent	10	NC	NC	NC	NC	NC	NC	140	NC	NC	NC	NC	NC	NC	1	4
Ningaloo Coast North	Emergent	2	NC	NC	7	NC	2	NC	5,575	NC	NC	122	NC	6,482	NC	449	204
Ningaloo Coast South	Emergent	9	NC	NC	NC	NC	66	NC	1,070	NC	NC	NC	NC	1,135	NC	38	85
Outer Shark Bay Coast	Emergent	15	NC	NC	NC	NC	NC	NC	172	NC	NC	NC	NC	NC	NC	3	13
Outer Ningaloo Coast North	Intertidal	NC	NC	NC	3	NC	NC	NC	NC	NC	NC	135	NC	NC	NC	NC	NC
Outer NW Ningaloo	Submerged	NA	22	NC	5	NC	NC	NA	NC	11.9	NC	165	NC	NA	NC	NA	NA
Offshore Ningaloo	Submerged	NA	5	NC	5	NC	NC	NA	NC	12.9	NC	205	NC	NA	NC	NA	NA

NC = no contact

NA = not applicable

7.6.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-10]

The control measures considered for this event are shown below (**Table 7-18**). EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-18: Control Measures Evaluation for a Subsea Release from the Production Well

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
NV-CM-61	Inspection of hydrocarbon containing equipment	IMMR includes inspection of hydrocarbon containing subsea systems and structures, including: + Subsea systems and structures + Static sections of flexible flowlines + Dynamic risers, dynamic umbilical's and associated mid-water buoyancy systems + Subsea Flexible Hoses + Mooring systems IMMR is set in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) which provides inspection frequencies (set at annual for GVI of subsea systems and structures). More frequent inspection may occur based on risk assessments (**Section 2.13.1**), scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment.	Costs associated with organisational time in writing, reviewing and implementing the IMM Plan. Costs associated with in field inspections (e.g. vessel use, use of ROV, organisational time).	**Adopted** – Benefits considered to outweigh costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Post-cyclone inspection by ROV may be able to provide additional surveillance of anomalies or areas of interest flagged by inspections or analysis.		
NV-CM-62	Production operating procedures	Procedures to ensure production operations are within the operating envelope to maintain the integrity of the subsea infrastructure. Operating within envelopes reduces unplanned spill risk.	Costs associated with organisational time in writing, reviewing and implementing the procedures.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-63	NOPSEMA accepted WOMP	The WOMP manages well integrity and all wells will be in compliance with the NOPSEMA accepted WOMP at all times. The WOMP includes control measures to manage well integrity risks to ALARP, including: + Barriers in place to isolate hydrocarbons from the marine environment + Inspection, monitoring and testing of barriers over the life of the well + Response to increases in well integrity risk + Notification and reporting requirements Effective barriers manage isolation of the reservoir from the environment, acting to eliminate hydrocarbon releases.	Costs associated with organisational time in writing, reviewing and implementing the WOMP.	**Adopted** – Benefits considered to outweigh costs. Regulatory requirement must be adopted.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-17	Navigational charting of infrastructure	Subsea infrastructure is charted on Australian AHS Nautical Charts so other users are aware.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – The positive benefits of identifying subsea infrastructure to other marine users outweighs the process of arranging their charting with AHS.
NV-CM-14	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – Risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km, is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-64	Testing of ESD and blowdown systems	ESD and blowdown systems will detect abnormal process conditions and alert the operators to execute preventative and mitigative actions on crude hydrocarbon containing equipment (including wells at the Christmas Trees). Functioning and tested ESD and blowdown systems ultimately prevent / minimise spill volumes and initiate blowdown and shutdown on hydrocarbon containing equipment during abnormal process, limiting any	Organisational costs associated with testing and ensuring testing takes place.	**Adopted** – Benefits of ensuring testing of ESD and blowdown systems occurs outweighs the costs to the organisation.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		release to the environment. ESD and blowdown systems are function tested in accordance with: + PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06) + PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08).		
NV-CM-65	Blowdown and flare system	Flare system is inspected, tested, and maintained in accordance with PS-09 Blowdown and flare system (NV-00-RG-10053.09). Subject equipment includes: + Blowdown Valves + Flare Tip Integrity + Nitrogen Flare Purge Valves A function tested blowdown and flare system seeks to prevent escalation of loss of containment through the depressurisation of process inventories. PS-09 aims to assure a functional blowdown system are available at all times that the associated plant is operational so escalation of spill events can be	Negligible organisational costs associated with inspections and maintenance of system.	**Adopted** – Benefits of ensuring inspections are undertaken and compliance is maintained outweigh the costs to the organisation.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		prevented by the depressurisation of process inventories via release to flare when initiated rather than marine environment.		
NV-CM-66	Oil Pollution Emergency Plan (OPEP)	Implements response plan to deal with an unplanned hydrocarbon spills quickly and efficiently in order to reduce impacts to the marine environment.	Organisational and administrative costs associated with preparing documents, ongoing management (spill response exercises) and implementation of OPEP.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.
NV-CM-67	Incident Response Plan detailing the requirements for preparedness and response to emergencies and crises to protect people and the environment.	Provides detail to ensure the ESD system is activated quickly and efficiently if it has not automatically activated, to reduce the extent of impacts to the marine environment.	Administrative costs of preparing documents.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-68	Santos' decommissioning framework implemented prior to EOFL (refer to **Section 8.8**).	Ensures an appropriate level of planning for the eventual permanent plug and abandonment of Van Gogh and Coniston Novara wells and removal of property unless otherwise approved by NOPSEMA. Ensures Santos has plans in place to meet its regulatory obligation to remove property in accordance with the requirements of s.572 of the OPGGS Act.	Organisational costs to prepare plans.	**Adopted** - Benefits considered to outweigh costs. Regulatory obligation to remove property.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Additional control measures				
N/A	Real time leak detection using pressure and temperature instrumentation	Would allow detection of a leak and subsequent environmental release to be detected immediately. Well would then be shut in.	Pressure and temperature instrumentation are ineffective at detecting fugitive leaks and emissions in the subsea environment.	**Rejected** -Control is not effective at detecting fugitive leaks and emissions in the subsea environment.
N/A	Continuous ROV monitoring of subsea system	Ensures that leaks are detected quickly during visual inspection of the valves. Adopted of the control would reduce the time a small leak is undetected, reducing the volume released to the environment.	The cost for 24-hour monitoring in field including vessel hire would be approximately $200K/day. Increased potential for risk to subsea infrastructure from ROV operations.	**Rejected** – Large cost associated deemed grossly disproportionate compared to risk.
N/A	Dedicated resources (e.g. dedicated spill response facilities on location) in the event of loss of hydrocarbons to allow rapid response.	May allow for quicker response to a spill as resources will be within close proximity.	Large costs associated with a dedicated resource on location.	**Rejected** – Large cost associated with dedicated resources on location deemed grossly disproportionate compared to risk.
N/A	Drill top holes of a relief well	Will allow for relief well to be drilled faster as top holes have been drilled.	Large cost associated with the MODU is estimated at approximately $555,000 per day. Multiple top holes would be required to be drilled in the fields. Additional environmental risks associated	**Rejected –** MODU is estimated at approximately $555,000 per day. Drilling of top holes may cause additional environmental impact which outweighs the benefits.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
			with drilling (vessel and MODU).	
N/A	MODU on standby for drilling a relief well	Will allow for relief well to be drilled immediately as MODU is on standby.	Large cost associated with the MODU is estimated at approximately $555,000 per day.	**Rejected –** MODU is approximately $555,000 per day, the cost of having a MODU on standby is disproportionate to the environmental benefit.
N/A	Source control plans in place for all wells.	May allow for quicker response to a loss-of-well-control scenario, thereby limiting potential spill extent and volume.	Costs associated with organisational costs and reviewing relief well plans.	**Rejected** – Santos only has relief well plans in place for wells undergoing intervention activities, and it is part of the intervention planning process. Given the low risk presented by wells and the standards used to manage well integrity, it is not considered an effective control.
N/A	Testing of ESD and blowdown systems at greater frequency than that detailed in relevant PSAPs	Little environmental benefit. PSAP approach (defined in Section determines function testing and inspection frequency. Testing frequency may be greater based on a risk based approach (e.g. inspections or analysis results) which indicate further testing and inspection is required. Unwarranted testing is determined to provide little to no integrity assurance benefits.	Costs associated with testing of ESD and blowdown systems at greater frequencies. Unwarranted testing also presents unwarranted safety and environmental risks.	**Reject** – Costs which grossly outweigh the environmental benefit. Unwarranted function testing and inspection greater than that of a risk based PSAP risk based approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
				environmental benefit.
N/A	Scheduled designated monitoring flights for leak detection	Helicopter flights for leak monitoring over the NV subsea infrastructure could potentially identify small leaks from the subsea system on the sea surface through oil sheen, initiating investigation into the leak source and ultimately reducing the duration of leak.	High cost involved with scheduling flights specifically for leak detection and training crew to observe. Relies heavily on suitable weather to allow for visual observation from the helicopter to notice a sheen on the surface.	**Reject** – Costs which grossly outweigh the environmental benefit. Leaks may be picked up opportunistically during routine crew change helicopter flights.

7.6.4 Environmental Impact Assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.6**

7.6.4.1 Identification of Hotspots for Consequence Analysis

As described in **Section 7.5.6**, all HEVs within the EMBA (low exposure value) are listed in **Table 7-19** below. The values and sensitivities associated with these HEVs have been described in **Appendix D1.** Further to this **Table 7-19** filters the HEV to identify the hotspots where they meet the criteria described in **Section 7.5.6.**

Table 7-19 Identified High Environmental Value and Hotspot Receptors

Receptor	HEV Value	Exposure Value			Hotspot*
		Low	Moderate	High	
Karratha-Port Hedland	5	✓			
Dampier Archipelago	3	✓	✓		
Northern Islands Coast	5	✓	✓		
Montebello Islands	3	✓	✓	✓	✓
Lowendal Islands	3	✓	✓		
Barrow Island	3	✓	✓	✓	✓
Middle Islands Coast	5	✓	✓		
Thevenard Islands	5	✓	✓		
Southern Islands Coast	5	✓	✓		
Muiron Islands	2	✓	✓	✓	✓
Exmouth Gulf Coast	2	✓	✓		

Ningaloo Coast North	2	✓	✓	✓	✓
Ningaloo Coast South	3	✓	✓	✓	✓
Carnarvon - Inner Shark Bay	2	✓			
Outer Shark Bay Coast	3	✓	✓		
Zuytdorp Cliffs - Kalbarri	3	✓			
Geraldton - Jurien Bay	3	✓			
Abrolhos Islands Pelsaert Group	2	✓			
Dawesville - Bunbury	4	✓			
Geographe Bay - Augusta	2	✓			
Augusta - Walpole	4	✓			
Indonesia - East	5	✓			
Indonesia - West	5	✓			
Mandurah - Dawesville	3	✓			
Jurien Bay - Yanchep	3	✓			
Perth Northern Coast	3	✓			
Christmas Island	4	✓			
Barrow Island	3	✓			
Barrow-Montebello Surrounds	3	✓			
Muiron Islands	2	✓			
Montebello AMP	4	✓			
Outer Ningaloo Coast North	1	✓	✓		✓
Outer NW Ningaloo	3	✓	✓		✓
Offshore Ningaloo	4	✓	✓		
Clerke Reef MP	3				
Glomar Shoals	5	✓			
Rankin Bank	5	✓			
Scott Reef South	3	✓			
Outer Abrolhos Islands - Shoals	3	✓			
Abrolhos Islands Easter Group	2	✓			
Perth Canyon AMP	2	✓			
Two Rocks AMP	2	✓			
Jurien AMP	2	✓			
Shark Bay AMP	4	✓			

Rowley Shoals surrounds	4	✓			
Deep Geographe - Augusta	3	✓			
Offshore Geographe - Augusta 1	2	✓			
South-west corner AMP	4	✓			
Offshore Geographe - Augusta 2	3	✓			
Abrolhos West	2	✓			
Offshore Abrolhos NW	4	✓			
Nearshore Abrolhos	4	✓			
Offshore Abrolhos - Perth North	4	✓			
Offshore Perth South - Geographe	4	✓			

* greater than 5% probability of contact

This process identified the following Hotspots:

+ Montebello Islands;
+ Barrow Island;
+ Muiron Islands;
+ Ningaloo Coast North;
+ Ningaloo Coast South;
+ Outer Ningaloo Coast North; and
+ Outer NW Ningaloo.

Table 7-20 provides a consequence assessment results for each of the Hotspot areas. The consequence assessment was based on predicted contact and concentration of surface oil, accumulated oil, entrained hydrocarbon and dissolved hydrocarbons. For each Hotspot area the consequence to the key values were assessed using the methodology described in **Section 7.5.6**.

Table 7-20: Hotspot Consequence Assessment Results from a Subsea Release of Hydrocarbon from a Production Well Leak - Summary for Priority Protection Areas for Focused Spill Response

Receptor Name	HEV Ranking	Values	Oil Spill Modelling Parameter		Surface Blowout (NC = No Contact)	Consequence Category	Consequence Ranking	Total
Montebello Islands	3	<u>Habitats</u> Reefs Algae (40%) Fish habitat Intertidal sand flat communities Mangroves (considered globally unique as they are offshore) <u>Turtles</u> Loggerhead and green (significant rookery), hawksbill, flatback turtles Northwest and Eastern Trimouille Islands (hawksbill) Western Reef and Southern Bay at Northwest Island (green) <u>Seabirds</u> Migratory and threatened seabirds – 14 species Significant nesting, foraging and resting areas <u>Whales</u>	*Probability of contact by surface oil at 10 g/m^2*	*(%)*	NC	+ Threatened or migratory fauna; + physical habitat; + protected areas; and + socio-economic receptors.	III IV IV IV	IV
			Maximum oil loading on shorelines <u>(worst-case deterministic)</u>	*Tonnes*	16			
			Maximum accumulated concentration (>100 g/m^2)	*g/m^2*	1,612			
			Maximum length of shoreline oiled <u>(>100 g/m^2)</u>	*(km)*	21			
			Minimum time to contact by surface oil 10 g/m^2	*Time (d)*	NC			
			Maximum total entrained	*(ppb)*	NC			

		Humpback/ pygmy blue whale migration Socio-economic Pearling (inactive/pearling zones) Very significant for recreational fishing and charter boat tourism Social amenities and other tourism Nominated place (national heritage)	*hydrocarbon when >100 ppb*					
			Maximum concentration of dissolved aromatic hydrocarbons >10 ppb	*(ppb)*	NC			
Barrow Island	3	Habitats Bandicoot Bay - conservation area Fisheries Act (benthic fauna/seabird protection), mudflats, rock platforms, mangroves, clay pans Mangroves in Bandicoot Bay (considered globally unique) Coral reefs (eastern side) – Biggada Reef Biggada Creek Turtles Regionally and nationally significant green turtle (western side) and flatback turtle (eastern side) nesting beaches Turtle Bay north beach North and west coasts – John Wayne Beach also loggerhead and hawksbill turtles Seabirds Migratory birds (important habitat) (important bird area) 10th of top 147 bird sites.	*Probability of contact by surface oil at 10 g/m^2*	*(%)*	NC	+ Threatened or migratory fauna; + physical habitat; + protected areas; + socio-economic receptors	III IV IV III	IV
			Minimum time to contact by surface oil 10 g/m^2	*Time (d)*	NC			
			Maximum oil loading on shorelines >100g/m^2	*(m^3)*	31			
			Maximum accumulated concentration >100g/m^2	*(g/m^2)*	1,612			
			Maximum length of shoreline oiled (>100 g/m^2)	*(km)*	38			
			Maximum concentration of entrained	*(ppb)*	NC			

		Highest population of migratory birds in Barrow Island Nature Reserve (south-southeast island). Double Island important bird nesting (shearwaters, sea eagles). <u>Cultural heritage</u> Important Aboriginal cultural; 13 listed sites incl. (pearling camps) <u>Socio-economic</u> Significant for recreational fishing and charter boat tourism Nominated place (National heritage)	*hydrocarbon >100 ppb*					
			Maximum concentration of dissolved aromatic hydrocarbon >10 ppb	*(ppb)*	NC			
Muiron Islands	2	<u>Turtles</u> Major loggerhead nesting, North and south Muiron sig. green turtle nesting, Hawksbill nesting too (low density), Occasional flatbacks <u>Seabirds</u> Significant bird breeding <u>Protected Areas</u> The Ningaloo Coast WHA includes Muiron Island Marine Management Area (including the Muiron Islands) <u>Socio-Economic</u> Exmouth gulf prawn fishery (Muiron is western boundary), Significant for recreational fishing and charter boat tourism Social amenities and other tourism	*Probability of contact by surface oil at 10 g/m²*	*(%)*	NC	+ Threatened or migratory fauna; + physical habitat; + protected areas; + socio-economic receptors	IV	IV
			Minimum time to contact by surface oil 10 g/m²	*Time (d)*	NC		IV	
			Maximum oil loading on shorelines >100g/m²	*(m³)*	86		IV	
			Maximum accumulated concentration >100g/m²	*(g/m2)*	5,328		IV	
			Maximum length of shoreline	*(km)*	17			

			oiled (>100 g/m²)					
			Maximum concentration of entrained hydrocarbon >100 ppb	*(ppb)*	104			
			Maximum concentration of dissolved aromatic hydrocarbon >10 ppb	*(ppb)*	NC			
Ningaloo Coast North	2	<u>Habitats</u> Contains part of the largest fringing reef in Australia Lagoonal., intertidal and subtidal coral communities 9 species of seagrass + macroalgae beds Mangrove bay – Significant mangroves Yardie Creek – Significant mangroves and tidal creek <u>Marine mammals</u> Seasonal aggregations of whale sharks, manta rays, sea turtles and rays. Whale sharks March-July Logger head turtles October - April Green Turtles Dec-March	*Probability of contact by surface oil at 10 g/m²*	*(%)*	NC	+ Threatened or migratory fauna; + physical habitat; + protected areas; + socio-economic receptors	IV V IV IV	V
			Minimum time to contact by surface oil 10 g/m²	*Time (d)*	NC			
			Maximum oil loading on shorelines >100g/m2	*(m³)*	449			

		Low density Hawksbill turtles Pygmy Blue Whale feeding <u>Seabirds</u> 33 species of seabirds and avifauna. Main breeding areas at Mangrove Bay, Mangrove Point, Point Maud, the Mildura Wreck Site and Fraser Island <u>Protected Areas</u> Includes 13 out of the 18 sanctuary zones under the state MP. World Heritage Areas Exmouth Peninsula Karst System is an official value of the National Heritage Area. <u>Socio-economic and heritage values</u> Tourism Recreational Fishing fishing and charter boat tourism	*Maximum accumulated concentration >100g/m²*	*(g/m²)*	6,482			
			Maximum length of shoreline oiled (>100 g/m²)	*(km)*	204			
			Maximum concentration of entrained hydrocarbon >100 ppb	*(ppb)*	122			
			Maximum concentration of dissolved aromatic hydrocarbon >10 ppb	*(ppb)*	NC			
Ningaloo Coast South	3	<u>Habitats</u> Contains part of the largest fringing reef in Australia Lagoonal, intertidal and subtidal coral communities 9 species of seagrass + macroalgae beds Mangroves <u>Marine mammals</u>	*Probability of contact by surface oil at 10 g/m²*	*(%)*	NC	+ Threatened or migratory fauna; + physical habitat; + protected areas; + socio-economic receptors	IV V IV	V
			Minimum time to contact by surface oil 10 g/m²	*Time (d)*	NC			
			Maximum oil loading on shorelines >100g/m²	*(m³)*	38			

		Seasonal aggregations of whale sharks, manta rays, sea turtles and rays. Whale sharks March-July Logger head turtles October - April Green Turtles December -March Low density Hawksbill turtles November - February Pygmy Blue Whale feeding <u>Seabirds</u> 33 species of seabirds and avifauna. Main breeding areas at Mangrove Bay, Mangrove Point, Point Maud, the Mildura Wreck Site and Fraser Island <u>Protected Areas</u> Includes 13 out of the 18 sanctuary zones under the state MP. World Heritage Areas Exmouth Peninsula Karst System is an official value of the National Heritage Area. <u>Socio-economic and heritage values</u> Tourism Recreational fishing fishing and charter boat tourism	*Maximum accumulated concentration >100g/m^2*	*(g/m^2)*	1,135		III	
			Maximum length of shoreline oiled (>100 g/m^2)	*(km)*	85			
			Maximum concentration of entrained hydrocarbon >100 ppb	*(ppb)*	NC			
			Maximum concentration of dissolved aromatic hydrocarbon >6 ppb	*(ppb)*	NC			
Outer Ningaloo Coast North	1	<u>Habitats</u> The Ningaloo Reef itself and its juxtaposition with coastal terraces,	*Probability of contact by surface oil at 10 g/m^2*	*(%)*	NC	+ Threatened or migratory fauna;	IV	V

		limestone plains, reef sediments. The contact of the reef by entrained oil may reduce the aesthetic appeal and diminish these values. Marine mammals Seasonal aggregations of whale sharks, manta rays, sea turtles and rays. Whale sharks March-July Logger head turtles October - April Green Turtles December -March Low density Hawksbill turtles November - February Pygmy Blue Whale feeding Socio-economic and heritage values Very significant for recreational fishing, game fishing and charter boat tourism Protected Areas World Heritage Areas Australian Marine Park	*Minimum time to contact by surface oil 10 g/m^2*	*Time (d)*	NC	+ physical habitat; + protected areas; + socio-economic receptors	V	
			Maximum oil loading on shorelines >100g/m^2	*(m^3)*	NC		IV	
			Maximum accumulated concentration >100g/m^2	*(g/m^2)*	NC		IV	
			Maximum length of shoreline oiled (>100 g/m^2)	*(km)*	NC			
			Maximum concentration of entrained hydrocarbon >100 ppb	*(ppb)*	135			
			Maximum concentration of dissolved aromatic hydrocarbon >10 ppb	*(ppb)*	NC			
Outer NW Ningaloo	3	Habitats The Ningaloo Reef itself and its juxtaposition with coastal terraces,	*Probability of contact by surface oil at 10 g/m^2*	*(%)*	4.5	+ Threatened or migratory fauna;	IV	V

		limestone plains, reef sediments. The contact of the reef by entrained oil may reduce the aesthetic appeal and diminish these values. Marine mammals Seasonal aggregations of whale sharks, manta rays, sea turtles and rays. Whale sharks March-July Logger head turtles October - April Green Turtles December -March Low density Hawksbill turtles November - February Pygmy Blue Whale feeding Socio-economic and heritage values Very significant for recreational fishing, game fishing and charter boat tourism Protected Areas World Heritage Areas Australian Marine Park	*Minimum time to contact by surface oil 10 g/m2*	*Time (d)*	22	+ physical habitat; + protected areas; + socio-economic receptors	V IV IV	
			Maximum oil loading on shorelines >100g/m2	*(m^3)*	NA			
			Maximum accumulated concentration >100g/m2	*(g/m^2)*	NA			
			Maximum length of shoreline oiled (>100 g/m2)	*(km)*	NC			
			Maximum concentration of entrained hydrocarbon >100 ppb	*(ppb)*	165			
			Maximum concentration of dissolved aromatic hydrocarbon >10 ppb	*(ppb)*	NC			

The following scenarios (as defined in **Section 7.6.1**) leading to a subsea release of hydrocarbons from a production well have been risk assessed at the moderate exposure value (**Section 7.5.5**) in the below:

+ Subsea release of Van Gogh crude blend from a production well as a result of an external impact
+ Subsea release of Van Gogh crude blend from a production well as a result of internal influence

7.6.4.2 Subsea release of Van Gogh crude blend from a production well as a result of an external impact

Receptors	Threatened, migratory, and local fauna Protected areas Physical environment and habitats Socio-economic receptors
Consequence	IV – Major

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values (**Section 7.5.5**) are described in **Table 7-16.**

<u>Threatened, Migratory, and Local Fauna</u>

With high winds (10 m/s), significantly higher rates of dispersion are predicted, with approximately 65% of the released oil dispersed into the water column after 24 hours (GHD, 2019) a net result of weathering the Van Gogh crude blend is effectively losing the remaining volatile fraction of the oil and leaving a further degraded, waxier and heavier crude oil in any spill incident (Intertek, 2018), which may persist for some time. The potential sensitive receptors in the surrounding areas of the release will include fish, marine mammals, marine reptiles and seabirds at the sea surface, as discussed in **Section 3.2.3** which may come into contact with Van Gogh crude blend leading to skin or eye irritation or oiling of the birds feathers (as described in **Table 7-16**). It is expected that a subsea Van Gogh crude blend release from subsea system release has the potential to result in an insignificant disruption to the breeding cycle for marine mammals.

The humpback whale (migration and resting) and pygmy blue (distribution, migration and foraging), BIAs overlap the moderate exposure threshold area. An unplanned release of Van Gogh crude is not expected to interfere with their migration activity. There is the potential for behavioural disruption to the individuals traversing the release.

Deteriorating water quality / chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (**Table 3-8**). Habitat modification, degradation and disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Given the location of the release, and volume of potential hydrocarbon release there is the potential for modification to or a decrease in the availability of quality habitat (shorelines/subsurface), particularly given the volumes of accumulated hydrocarbons (maximum volume of hydrocarbon accumulation is at Ningaloo Coast North – 449 tonnes) and persistence of crude. Shoreline accumulation may have a major disruption on shoreline individuals (as described in **Table 7-16**). Volumes of accumulated hydrocarbons may result in a major reduction in area available for seabirds and/or turtle species. The quality of habitat (shorelines/subsurface) may be reduced for a period, with recovery over decades.

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves states that DPaW should 'ensure that important seabird and shorebird breeding and feeding areas are not significantly affected by human activities. The potential impacts of a hydrocarbon release on seabird breeding and feeding areas are discussed in **Table 7-16**. Impacts in relation to human activities from responding to a spill are described in **Section 6.8**.

<u>Physical Environment and Habitats</u>

In the event of Van Gogh crude blend release, hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a long-term decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. The quality of habitat may be reduced for a significant period with recovery over decades.

As described above, accumulated hydrocarbons on shorelines could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill. Beaches on the Ningaloo Coast are important for green turtles, and to a lesser extent hawksbills turtles, while Muiron Islands has a regionally important nesting site for loggerhead turtles. Impacts to turtles could occur from surface hydrocarbons if oil accumulates on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. The quality of habitat available to the turtles will be reduced, with recovery over decades.

<u>Protected Areas</u>

The moderate exposure values area intersects several protected areas and AMPs and marine management areas (impacts discussed in **Table 7-16** and AMP details presented in **Section 3.2**). Combined, these areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described in **Table 7-16** and impact on the values of these reserves could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves.

<u>Socio-economic Receptors</u>

There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. A major spill would result in the establishment of a safety exclusion zone around the affected area. A temporary prohibition on fishing activities for may be in place for period of time, and subsequently there is a potential for economic impacts to those affected. Hydrocarbon may also foul fishing equipment which will require cleaning or replacement.

Fish exposure to hydrocarbon can result in ‘tainting’ of their tissues. Even very low levels of hydrocarbons can impart a taint or ‘off’ flavour or smell in seafood. Fish have a high capacity to metabolise these hydrocarbons, while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). 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 (Yender et al. 2002).

Heritage values are not predicted to be impacted by surface oil although in the short-term there would be an impact on the aesthetic value of the area.

A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A Van Gogh crude blend subsea release from a well leak has the potential to disrupt these activities if contacted at moderate or high surface exposure values. with associated economic impact, albeit on a temporary basis.

Tourism could be affected by spilled Van Gogh crude blend, either from reduced water quality/shoreline oiling preventing recreational activities or reducing aesthetic appeal or from impacts to habitats and marine fauna. marine nature-based tourist activities, resulting in a loss of revenue for operators.

Indigenous users may be impacted if a land-based response is required. However, consultation will help manage activities such that potential impacts are reduced to acceptable levels. Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon release were to occur as fish may be ‘tainted’ as described above.

Based on the above assessments, a Van Gogh crude blend subsea release from a well leak, has the potential to impact an array of receptors. Given the extent, the worst-case consequence is considered to be *Major (IV).*

Likelihood	Remote

In accordance with the Santos Risk Matrix, a worst-case subsea release of Van Gogh crude blend from a production well as a result of an external impact has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of Van Gogh crude blend from a production well resulting in a *Major (IV)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Low**

7.6.4.3 Subsea release of Van Gogh crude blend from a production well as a result of internal influence

Receptors	Threatened, migratory, and local fauna Protected areas Physical environment and habitats Socio-economic receptors
Consequence	III - Moderate
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values (**Section 7.5.5**) are described in **Table 7-16.** The size of release from a well leak from internal influence is significantly smaller than the credible subsea release of Van Gogh crude blend from a production well as a result of an external impact, which has been modelled (**Section 7.6.2.2**) and risk assessed (**Section 7.6.4.2**). Given the size of the release (114 m^3 over 465 days) a subsea release of Van Gogh crude blend from well leak from internal influence will impact local marine fauna in the immediate site of release and relate to short term behavioural change. Impacts to water quality will be localised but detectable and occur for a short duration whilst the release disperses. Rapid recovery is expected. A subsea release of Van Gogh crude blend from subsea release of well leak from internal influence has the potential to insignificantly impact local marine fauna and physical environments and habitats. Given the release size, the worst-case consequence is considered to be *Moderate (III).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of Van Gogh crude blend from a production well as a result of internal influence has been defined as a 'Remote' event as it ' requires exceptional circumstances and is unlikely even in the long term'. This likelihood aligns with a frequency of 1 in 100 years. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of Van Gogh crude blend from a production well as the result of internal influence resulting in a *Moderate (III)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Low**

7.6.5 Demonstration of ALARP

Since the purpose of operational activities is to extract, process, store and offload crude oil, the risk of a subsea crude oil spill cannot be eliminated from the operational area.

External impact controls

The location and depth (340-400 m) of the operational area reduces the likelihood of external vessels impacting the production wells. The depth of water is too deep for vessel anchoring. Drilling activities are not proposed under this environment plan and therefore any rig anchoring required in the operational area will be managed under a separate environment plan. While trawling could potentially be used by the North West Slope Trawl Fishery, the operational area has not been historically fished with effort restricted to east of the Montebello/ Barrow/ Lowendal Islands. Consultation with the fishing industry is included in **Section 4** of this EP.

Vessels undertaking IMMR activities are required to have dynamic positioning allowing subsea inspection activities to be performed without anchoring and eliminating the risk of anchor dragging. The use of redundancy in the positioning system provides assurance that inspection activities will not damage subsea infrastructure through dragging objects (e.g. ROVs).

The primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005). This system responds to both automatic and manual activation, with automatic activation triggered by abnormal process conditions, such as pressure drop across the subsea production system. The emergency shutdown system functionality and reliability is maintained through regular testing of the shutdown systems and the subsea valves. The regular testing and maintenance of the emergency shutdown and blowdown systems are managed through Performance Standard Assurance Plans (PSAPs), which provide the work instructions and performance criteria to test and service the shutdown and blowdown systems. The relevant PSAPs contain specific performance criteria as detailed below:

+ PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06). The performance criteria specified in PS-06 includes:
  - ESDV locations, ESDV actuation requirements, Valve travel timings, acceptable leakage rates for riser ESDVs.
+ PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) for the Well and Tree Valves except for the water injection wells. The performance criteria specified in PS-07 includes:
  - Master valve and wing valve testing and leak rate requirements, Master and Wing valve closure requirements, hydraulic system dump capabilities
+ PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). The performance criteria for Safety instrumented Systems in PS-08 includes:
  - The Safety Integrated system shall initiate shutdown and blowdown of the process during abnormal process conditions in accordance with the Cause and Effects Diagrams and alarm and trip schedule, ESD pushbutton locations, Reliability/availability achievements through redundancy, backup power, regular function testing and self-diagnostic capability.

The relevant PSAPs are listed as control measures with relevant performance standards in **Table 8-2.**

The maintenance and regular testing of the ESD and blowdown system and the subsea valves managed through the PSAPs ensures a functional, available, reliable, survivable independent control ensuring the emergency shutdown and blowdown functionality, resulting in near-instantaneous shut in following loss of pressure and is considered to reduce the spill volume to ALARP for a major leak/rupture scenario.

A functioning and tested ESD and blowdown system in accordance with the relevant PSAPs is designed retain liquid in on board and blowdown gas rather than discharge to the environment in the event of an emergency situation. Other means of mitigating an emergency situation (such as over pressure) may be to discharge or release hydrocarbon to the marine environment. The NV ESD and blowdown system is therefore considered ALARP.

Function testing and inspection frequency and intervals within Santos PSAPs are based on a combination of:

+ Industry recommendations / standards
+ Manufacturers recommendations
+ Statutory obligations
+ Integrity risk (based on previous inspections or other triggers)

Unwarranted function testing and inspection greater than that of a PSAP approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit.

A PSAP deviation process is detailed in the Santos Permitted Operations Procedure (QE-00-IG-00183), which provides allowance for deferral of PSAP assurance activities on a completion of a risk assessment process, which shows safe operations can continue and integrity can be maintained. Further details on this process is provided in **Section 8.3.1.1**.

<u>Internal influence controls</u>

As described above for external impact, the primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system, managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005). PSAPs provide the work instructions and performance criteria to test and service the shutdown and blowdown systems.

The NOPSEMA approved WOMP includes control measures to prevent loss of well integrity and well control, including specified barriers. Operating in accordance with the WOMP is considered ALARP.

IMMR includes an annual GVI of hydrocarbon containing subsea systems and structures. IMMR is in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007). which provides inspection frequencies, scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment. IMMR campaigns may also opportunistically identify small leaks during inspections, otherwise undetected through the NV control room or production data review, through the annual GVI. Hence, the annual GVI subsea leak inspection may be completed in a number of campaigns within the calendar year.

Frequencies for IMMR is based on a schedule set within Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) (see **Table 2-9**) and includes nominal inspection frequencies and a commitment to an annual GVI inspection of hydrocarbon containing subsea systems and structures. The nominal IMMR frequencies and intervals may also be increased on the basis of (**Section 2.13.1**). Risk assessments are undertaken following physical events, integrity assessments or other triggers (e.g. inspections or analysis results). Based on these risk assessments additional GVI may be performed. Conducting IMMR when not required presents unwarranted risks (e.g. risks associated with vessel use, marine growth removal) and additional costs which grossly outweigh the environmental benefit.

A number of controls in addition to the IMMR were investigated to detect small leaks:

+ Continuous use of the ROV for monitoring of leaks.
+ Realtime monitoring of the wells for small leaks using pressure and temperature instrumentation.
+ Scheduling specific flights for leak detection through identification of sheen.

As detailed in **Table 7-18**, these controls either are ineffective or costs associated grossly outweigh the environmental benefits. As such, the use of IMMR to mitigate and detect leaks (including those undetected through monitoring the production data) with an annual frequency set for GVI of the hydrocarbon containing elements of the subsea production system, and the ability to increase frequency based on output of a risk assessment approach has been determined ALARP.

Santos considers that through the resourcing arrangements outlined within the OPEP (including spill response equipment and personnel from internal and external sources including Santos, AMOSC, AMSA, other operators, OSRL, and other national and international suppliers) the spill response strategies and control measures reduce potential risk and impacts from to ALARP. Placement of response equipment (e.g. booms) on location (the FPSO or support vessels), ready to respond to a loss of hydrocarbons event was investigated; however the cost of upkeep and the space required for the equipment was determined to be grossly disproportionate to the benefits. In addition, the financial costs of having a MODU on standby to drill a relief well should a leak occur is disproportionate to the environmental benefit.

In the instance of a well leak the impacts are deemed to be ALARP on the basis that the likelihood is low and no further controls would further reduce the likelihood. In addition to this, the controls within the WOMP are designed to confirm if any release is occurring and to respond to that event in a timely manner. On this basis the potential consequence is also reduced to ALARP.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos have where practicable, adopted all reasonable controls for reducing the risk.

The ongoing general inspection and maintenance regime that is completed in accordance with the NOPSEMA-accepted WOMP and Santos procedures, ensures that property is maintained in good condition and repair until the point in time when the property is removed from the title.

It is through the development and eventual implementation of the Decommissioning Plan that Santos will meet its obligations under s. 572 (3) of the OPGGS Act ‘to remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations’.

With the above control measures in place, Santos deem that the activity risk from an unplanned release of Van Gogh crude blend from the well leak is ALARP.

7.6.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes –Residual risk is ranked as Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with OPGGS (2009) Regulations including Safety Case and WOMP. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities (**Section 3.2**) including the Muiron Island Marine Management Area, Ningaloo Australian Marine Park.; and Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015)

	+ Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016) + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016) + Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

The likelihood of a subsea hydrocarbon release (Van Gogh crude) from a well leak from an external event is extremely low (remote) when considering industry statistics on the event, Santos statistics and the preventative controls in place. Additional industry standard control measures to reduce the chance of the event occurring (and minimise impacts) have also been implemented including (but not limited to) inspection monitoring and maintenance of subsea infrastructure, production operating procedures, NOPSEMA accepted WOMP, navigational and petroleum safety and cautionary zones and spill response (OPEP).

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this unplanned event from the NV Operations.

In accordance with Santos risk assessment process, the residual risk is Low and ALARP. The proposed control measures will reduce the risk of impacts from a subsea Van Gogh release (crude or dry gas) from a well leak to a level that is considered acceptable.

7.7 Subsea Release of Hydrocarbon from the Subsea System to the Marine Environment

7.7.1 Description of Event

Event	The subsea system includes all hydrocarbon containing components (excluding wells) detailed with **Section 2.3**. For example, the DTM buoy, flowlines and risers, produced water flowlines. The following three scenarios may result in a Van Gogh crude blend being released from the subsea system: **No.** | **Scenario** | **Maximum credible volume** 1 | Subsea release of Van Gogh crude blend from a subsea system rupture due to external impact | 1,681 m^3 over 24 hours 2 | Subsea release of Van Gogh crude blend from a subsea system leak due to internal influence - detected within 1 day | 150 m^3 over 36 hours 3 | Subsea release of Van Gogh crude blend from a subsea system leak due to internal influence - potentially undetected for up to 365 days | 638 m^3 up to 365 days 1. Subsea release of Van Gogh crude blend from a subsea system rupture due to external impact. External impact to the subsea system includes events such as dropped/dragged objects, dropped equipment/materials or anchor/chain drag. When the FPSO is off location the DTM buoy is submerged approximately 30 m below the sea-surface, the 500 m PSZ remains in place during this period. The worst-case volume and rate of crude oil released from the subsea system has been based on the AMSA (2015) guideline: *Technical guideline for the preparation of marine pollution contingency plans for marine and coastal facilities*. Specifically, the calculation presented for an offshore pipeline rupture has been used since a rupture of a flowline within the subsea system will result in the largest potential volume of Van Gogh crude released from the subsea system. AMSA (2015) determines the volume release from an offshore pipeline rupture as the maximum daily flow rate x 1 hr + volume of oil in the pipeline / flowline. Major loss of containment of the NV subsea system would be detected and result in an instantaneous ESD which isolates the inventory of the hydrocarbon; however, failures of multiple barriers have been assumed for conservatism in which case 1 hr has been allowed before manual detection and isolation may occur. The single flowline maximum oil flow rate prior to isolation has been calculated as 5,009 m^3 /day (31,500 bopd). There are crossover lines (header selector valves) connecting the two production flowlines and current operations have the valves between flowlines at one manifold open (the remaining manifold crossover valves are closed); therefore, once isolated the inventories in both flowlines could be released. The maximum release volume from the subsea system has therefore been calculated based on maximum daily flow rate (single flowline, 5,009 m^3 /day (31,500 bopd) x 1 hr + volume of crude in largest isolatable section (volume in both flowlines is 1,472 m^3). The maximum credible release from a rupture event is 1,681 m^3, released through the rupture over 24 hours on an exponential rate of decline, as per **Figure 7-5** and **Table 7-21**.

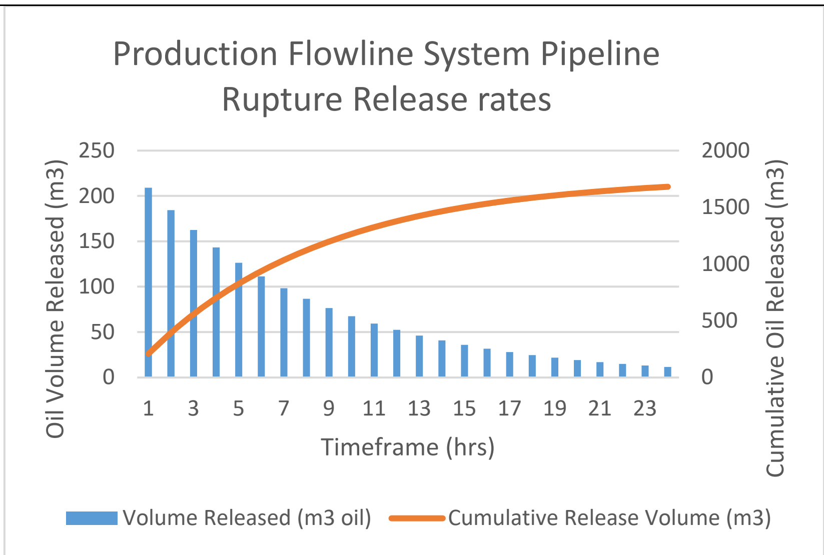

Figure 7-5: Subsea system release rates

Table 7-21: Pipeline rupture release rate profile

Release Rate Profile		
Timeframe (hr)	**Volume Released (m^3 oil)**	**Cumulative Release Volume (m^3 oil)**
1	209	209
2	184	393
3	162	556
4	143	699
5	126	825
6	111	937
7	98	1035
8	87	1122
9	76	1198
10	67	1265
11	59	1325
12	52	1377
13	46	1423
14	41	1464
15	36	1500
16	32	1531
17	28	1559
18	25	1584
19	22	1605
20	19	1624
21	17	1641
22	15	1656
23	13	1669
24	12	1681

2. Subsea release of Van Gogh crude blend from a subsea system leak due to internal influence – detected within 1 day

Internal influences on the subsea system include events such as corrosion, valve/flange failure, equipment failure within the subsea system.

The AMSA guidelines (2015) were developed to allow a consistent approach across industry to quantify pipeline discharge volumes (including small leaks in offshore flowlines), and it provides the industry-best practice to quantification of the small leak potential of the NV subsea production system.

AMSA (2015) determines the volume release from an offshore pipeline / flowline leak as 2% of the maximum daily flow rate x 1 day (time to detect the leak) + time taken to clear/flush pipeline. As justified below (**Table 7-22**), the estimate of the time taken to shut down NV oil production wells, and flush the subsea system with water is 12 hours.

Table 7-22: Indicative time taken to shut down wells and flush NV flowlines

Activity	Activity Duration
Shut down production wells and start-up 100% water well at maximum rate (conservative assumption of 21,000 stb/d = 3,338 m^3/d). It typically takes (in non-emergency situations) 1hr to start up a well to peak rate.	1 hrs
Flush flowline volume	11 hrs
Total indicative time taken to flush flowlines	**12 hrs**

The small leak potential calculation in accordance with AMSA guidelines can thus be calculated as follows:

2% x 5,009m^3/day x 1 day (time to detect the leak) = 100.2 m^3

+

12 hours (0.5 days) x 100.2m^3/d = 50.1 m^3

Total release with 2% leak = 150.2 m^3 over ~36 hours.

Total Volume Released over 36 hours
150.2 m^3 oil

A release of this nature would be detected by the NV control room through system behaviour, or on the sea surface, through a visible sheen within a day (which could be detected by a range of surface activities e.g. vessels, flights, discussed in the scenario below). Lesser internal influence release scenarios which may go undetected for greater periods are discussed below.

3. Subsea release of Van Gogh crude blend from a subsea system leak due to internal influence – potentially undetected for up to 365 days

To determine the lower detection threshold for subsea crude leaks that will be detectible through visible and regular oil sheen events at surface, numerical oil spill dispersion modelling was conducted for a range of leak rates from producing subsea infrastructure. The threshold for visual detection of oil sheen events is accepted as an oil on water thickness of 1um or greater (> 1g/m^2) under the Bonn Agreement Oil Appearance Code (2007). Any isolated visible oil sheens at surface in the operational area will represent a deviation from the norm in the local environment where they cannot be clearly attributed, and Santos' demonstrated strong environmental surveillance and reporting culture will detect and respond to visible oil sheens if they start to occur.

Historic and forecast future activities of the field show a high level of Santos, second party (activities under contract to Santos) and third party (other users of the local area) activity which could detect visible oil sheen, this includes:

Surface activity includes, but not limited to:

+ A manned FPSO,

	+ Normally two helicopter flights per week during daylight hours, + Support Vessels transiting the area normally on a weekly basis, + Cargo tanker operations typically twenty times per annum, + Other Operators within the local area with a surveillance and reporting culture and similar associated FPSO, helicopter and vessel activity, + Third-party users of the area with a strong environmental reporting focus. Subsea Vessel and ROV activity includes, but is not limited to: + Subsea IMMR campaigns, GVI ROV activities which occurs at least annually (refer to Section 2.13.1). + Drilling Rig and associated ROV activity over the drill centres + Subsea Construction Vessel and ROV activity over the infrastructure + Environmental inspections sampling and data collection These activities demonstrate a continuous surveillance and reporting presence within the operational area and would result in detection of oil sheen events at surface should they ever occur. Numerical modelling was conducted to determine the lowest oil rate that would reliably present frequent isolated oil sheen events in the area. Simulations were iteratively conducted for leaks at 99stb/d, 50stb/d, 25 stb/d, and 12 stb/d over a period of 365 days, to locate the threshold for regular oil sheen events at surface (GHD, 2020). Reasonable engineering assumptions were made in relation to the leak orifice (a 20mm defect in a connection or flowline) and GOR (solution GOR of Van Gogh Crude). Leaks between 99stb/d (15.74 $m^{3/}d$) and 12. stb/d (3.81 m^3/d) were determined to result in a regular frequency of visible oil sheen events at the sea surface across the operations area and beyond, it is assessed these sheens would be detected by a range of surface activities e.g. vessels, flights etc. within weeks to months. Leaks less than 11 stb/d (1.75 m^3/d) would present minimal to sporadic isolated oil sheen events at surface and it would most likely be detected visually via one of the ROV activities occurring over the subsea infrastructure (historically these have occurred annually, see **Section 2.13**). Detection and mitigation leaks less than 11 stb/d are expected within a very conservative estimate of < 12 months via subsea ROV visual identification. If an 11 stb/d (1.75 m^3/d) leak went undetected for the full 365 days the maximum volume released is 638 m^3. The maximum credible release of hydrocarbon from the subsea system is therefore 1,681 m^3 released over 24 hours on an exponential rate of decline.
Extent	Stochastic modelling for a subsea release of Van Gogh crude blend from a subsea system rupture (Scenario 1) due to external impact, presents the maximum hydrocarbon extent of a subsea release and is based on moderate exposure values (**Section 7.5.5**), in summary: + Surface oil may occur out to 215 km from the release location. + Entrained hydrocarbon may occur out to 250 km from the release location. + Shoreline accumulation may occur a number or receptors, the furthest being Geraldton - Jurien Bay, approximately 1,000 km from the release location. + Dissolved hydrocarbons are highly local to the release.
Duration	<u>Scenario 1 (Rupture)</u>: 24 hours for Van Gogh crude blend to be released from the subsea system rupture.

	Scenario 2: Detected within 24 hours Scenario 3: Maximum of 365 days detect a leak of 11 stb/d (1.75 m^3/d)

7.7.2 Nature and Scale of Environmental Impacts

Hydrocarbon spills will cause a decline in water quality and may cause chemical (e.g. toxic) and physical impacts to marine species (e.g. coating of emergent habitats, oiling of wildlife at sea surface). The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (i.e. extent, duration) and sensitivity of the receptor.

Potential receptors: Shallow benthic, intertidal and shoreline habitats; plankton; invertebrates; fish; marine mammals; marine reptiles; birds (seabirds and shorebirds); fisheries; oil and gas industry; tourism; KEFs; and State and Commonwealth marine reserves and Australian Marine Parks.

A subsea release of Van Gogh crude blend from a subsea system release would result in a localised reduction in water quality in the upper surface waters of the water column in the immediate vicinity of the spill location and may result in Van Gogh crude blend contacting shorelines.

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are further described in **Table 7-16.**

Dry gas releases have been discussed in **Section 7.11.**

7.7.2.1 Hydrocarbon Weathering Behaviour

Refer **Section 7.6.2**.

7.7.2.2 Spill Modelling Results

To determine the spatial extent of impacts from a potential subsea release of Van Gogh crude blend from the subsea system (flowline) (Scenario 1) and the dispersion characteristics over time, modelling was completed by GHD (GHD, 2019). A volume of 1,681 m^3 released subsea over 24 hours was modelled. Internal influence leak scenarios have been the subject of leak modelling (GHD, 2020) and showed that the extent of the release will be contained within this spatial extent.

Modelling results from a volume of 1,681 m^3 released subsea over 24 hours have been provided for each of the four hydrocarbon fates: shoreline accumulation; surface; dissolved and entrained.

The modelling results are presented for the fate of hydrocarbon at the exposure values defined in **Section 7.5.5.** has been provided for the purposes of risk evaluation, displaying the following parameters:

+ Minimum time to contact from moderate and high exposure value;
+ Maximum hydrocarbon concentration from high exposure value;
+ Maximum hydrocarbon accumulation on shoreline from moderate and high exposure value; and
+ Length of shoreline oiled.

Further parameters required to inform spill response strategies are described further in the NV Operations OPEP (TV-00-RI-00003.02).

Surface Oil

Low

Stochastic modelling determined that surface oil at concentrations equal to or greater than 1 g/m^2 could extend up to 350 km from the release location. HEVs with the potential to be contacted at the low exposure values are:

+ Montebello Islands;
+ Barrow Island;
+ Barrow-Montebello Surrounds;
+ Ningaloo Coast North;
+ Montebello AMP;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Moderate and High

Stochastic modelling determined that surface oil at moderate exposure value of 10 g/m^2 may occur out to 215 km from the release location. HEVs with the potential to be contacted at the moderate exposure values are:

+ Ningaloo Coast North;
+ Montebello AMP;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Surface oil at the high exposure value of 50 g/m^2 may occur out to 100 km from the release location.

<u>Dissolved Hydrocarbons</u>

Low

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 10 ppb and above were not exceeded.

<u>Entrained hydrocarbon</u>

Low

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 10 ppb may occur out to 900 km from the release location.

Moderate and High

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 100 ppb may occur out to 250 km from the release location. At the moderate exposure value there is greater than 1% probability of entrained hydrocarbon reaching four HEVs: Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo. Outer NW Ningaloo and Offshore Ningaloo HEVs may be contacted at the high exposure value of 500 ppb.

<u>Shoreline Accumulation</u>

Low

Shoreline accumulation above the low exposure value may occur at 16 HEVs with the furthest from the release location being Geraldton - Jurien Bay, approximately 1,000 km from the release location.

Moderate

Shoreline accumulation above the moderate exposure value of 100 g/m^2 may occur at 7 HEVs:

- Montebello Islands;
- Barrow Island;
- Thevenard Islands;
- Muiron Islands;
- Exmouth Gulf Coast;
- Ningaloo Coast North;
- Ningaloo Coast South; and
- Outer Shark Bay Coast.

The furthest being Outer Shark Bay Coast, approximately 400 km from the release location.

High

Shoreline accumulation above the high exposure value of 1,000 g/m^2 may occur at three HEVs: Montebello Islands, Muiron Islands and Ningaloo Coast North.

Table 7-23: Summary of Hydrocarbon Contact with Receptors: 1,681 m^3 Subsea Crude Release

Receptor	Receptor Type	Minimum time to contact (days)							Maximum hydrocarbon concentration							Maximum oil ashore (tonnes)	Maximum length of oiled shoreline (km)
		Moderate exposure values				High exposure values			Moderate exposure values				High exposure values				
		Shoreline accumulation 100 g/m^2	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50 g/m^2)	Shoreline accumulation (100 gm^2)	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50g/m^2)	Shoreline accumulation (100 g/m^2)	Shoreline accumulation (100 g/m^2)
Montebello Islands	Emergent	8	NC	NC	NC	NC	8	NC	1,259	NC	NC	NC	NC	17	NC	18	17
Montebello AMP	Submerged	NA	7	NC	NC	NC	NC	NC	NC	12	NC	NC	NC	NC	NC	NA	NA
Barrow Island	Emergent	7	NC	NC	NC	NC	NC	NC	770	NC	NC	NC	NC	NC	NC	5	9
Thevenard Islands	Emergent	6	NC	NC	NC	NC	NC	NC	160	NC	NC	NC	NC	NC	NC	NC	NC
Muiron Islands	Emergent	3	NC	NC	NC	NC	3	NC	3,113	NC	NC	NC	NC	47	NC	41	11
Ningaloo Coast North	Emergent	1	1	NC	2	NC	1	1.8	14,929	92	NC	189	NC	604	100	647	142
Outer Ningaloo Coast North	Intertidal	NA	<1	NC	<1	NC	NC	1.1	NC	88	NC	158	NC	NC	101	NA	NA

Outer NW Ningaloo	Submerged	NA	<1	NC	<1	NC	NC	0.3	NC	126	NC	393	NC	NC	144.7	NA	NA
Offshore Ningaloo	Submerged	NA	<1	NC	<1	NC	NC	0.1	NC	189	NC	462	NC	NC	190	NA	NA
Ningaloo Coast South	Emergent	7	NC	NC	NC	NC	NC	NC	768	NC	NC	NC	NC	NC	NC	75	127
Outer Shark Bay Coast	Emergent	19	NC	NC	NC	NC	NC	NC	107	NC	NC	NC	NC	NC	NC	NC	NC

NC = no contact

NA = not applicable

7.7.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-09].

The control measures considered for this event are shown below (**Table 7-24**) EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-24: Control Measures Evaluation for Subsea Release from the Subsea System

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
NV-CM-61	Inspection of hydrocarbon containing equipment	Inspection, Maintenance and Monitoring (IMM) includes inspection of hydrocarbon containing subsea systems and structures, including: + Subsea systems and structures + Static sections of flexible flowlines + Dynamic risers, dynamic umbilicals and associated mid-water buoyancy systems + Subsea Flexible Hoses + Mooring systems IMM is set in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) which provides inspection frequencies (set at annual for GVI of hydrocarbon containing subsea systems and structures), scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment. Post-cyclone inspection by ROV may be also	Costs associated with personnel time in writing, reviewing and implementing the IMM Plan. Costs associated with in field inspections (e.g. vessel use, use of ROV, personnel time).	**Adopted** – Benefits considered to outweigh costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		able to provide additional surveillance of anomalies or areas of interest flagged by inspections or analysis.		
NV-CM-69	Inspection and corrosion monitoring of risers	Risers and flowlines, including all mounted fittings, fixtures and supports are inspected, tested, and maintained in accordance with PS-03 Hydrocarbon Containment; Risers and Pipelines (NV-00-RG-10053.03) Equipment includes: + Topsides risers + Annulus vent system + Subsea risers This aims to ensure the integrity and functioning of risers are fit for purpose and able to provide hydrocarbon containment.	Organisational costs associated with inspections.	**Adopted** – Benefits of ensuring inspections are undertaken and compliance is maintained outweigh the costs of personnel time
NV-CM-70	Mooring equipment integrity	PS – 28 Mooring (NV-00-RG-10053.28) maintains mooring equipment integrity and function. PS – 28 assures integrity of the mooring equipment through inspection and testing so that the FPSO remains within the DTM excursion limits therefore cannot impact risers, and lead to a hydrocarbon release. Equipment includes: + DTM Position Monitoring + System + Hawser Hook + Mooring system	Negligible personnel costs associated with inspections and testing.	**Adopted** – benefits of ensuring inspections are undertaken and compliance is maintained outweigh the costs of personnel time

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-71	DTM excursion limit	As per DTM System Daily Monitoring and Immediate Actions Procedure (NV-22-IU-10001). An excursion alarm is functioning to alert the NV operator when excursion limits are exceeded. The operator can then bring the FPSO within the limit, ultimately mitigating against impact to the risers and subsequent releases	Organisational costs associated with maintaining alarm and monitoring excursion	**Adopted** – Benefits considered to outweigh costs.
NV-CM-72	Swivel functionality	A functioning and tested swivel will maintain hydrocarbon containment of the swivel and DTM buoy systems whilst allowing FPSO rotation around the DTM buoy. Inspection and function requirements for the swivel is detailed in PS-30 Swivel and DTM buoy (NV-00-RG-10053.30). Equipment includes: + Turret and swivel system + DTM buoy + DTM system The swivel and DTM buoy system allows for process, power, control and chemical connections between vessel and subsea infrastructure. It also aims to support risers and umbilical in a connected / disconnected state.	Organisational costs associated with maintaining a functioning swivel	**Adopted** – Benefits of ensuring swivel is functional outweigh the costs

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-73	SIMOPs plans and procedure	Vessels undertaking a project/campaign activity (as opposed to IMMR activities) will undertake activities in accordance with a SIMOPS and procedures which reduces potential for interactions between FPSO operation and campaign which could cause a loss of hydrocarbons.	Costs associated with developing SIMOPs plans and procedure and cost associated with implementation.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-74	DTM Reconnection Procedure	Implementing DTM Reconnection Procedure (TV-22-IG-00061) prevents and mitigates loss of containment during the reconnection of the FPSO to the DTM turret. The procedure includes: + Reconnection stage instructions. + Inspection checks + Reconnection criteria (i.e. weather, forecasts) + Pre-connection testing and familiarisation.	Costs associated with personnel time in writing, reviewing and implementing the procedure	**Adopted** – Benefits considered to outweigh costs.
NV-CM-75	DTM Dis-connection Procedure	Implementing the DTM Disconnection Procedure (TV-22-IG-00062) prevents and mitigates loss of containment during the disconnection of the FPSO to the DTM turret. The procedure includes: + Disconnection criteria (i.e. weather, forecasts) + Inspection checks + Depressurisation, flushing and purging of riser connections.	Costs associated with personnel time in writing, reviewing and implementing the procedure	**Adopted** – Benefits considered to outweigh negligible personnel costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-17	Navigational charting of infrastructure	Subsea infrastructure is charted on Australian AHS Nautical Charts so other users are aware.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – The positive benefits of identifying subsea infrastructure to other marine users outweighs the process of arranging their charting with AHS.
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – Risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5nm, is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-14	Dropped object prevention controls	Reduces the risk of impact to subsea infrastructure from dropped objects through procedures and standards for lifting equipment inspection and maintenance and lifting procedures.	No additional costs to Santos other than negligible personnel costs of reviewing information.	**Adopted –** environmental benefits of identifying new sensitivities outweighs the low costs of implementing measure.
NV-CM-05	Vessels Planned Maintenance System	Reduces likelihood of dropped objects because lifting equipment is operating within its parameters.	Operational costs and labour/access requirements of undertaking equipment maintenance on vessels.	**Adopted** – Benefits of operating equipment within operational parameters will help reduce the likelihood of dropped objects.
NV-CM-65	Blowdown and flare system	Flare system is inspected, tested, and maintained in	Negligible personnel costs associated with	**Adopted** – benefits of ensuring inspections are

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		accordance with PS-09 Blowdown and flare system (NV-00-RG-10053.09).Equipment includes: + Blowdown valves + Flare tip integrity + Nitrogen flare purge valves A function tested blowdown and flare system seeks to prevent escalation of loss of containment through the depressurisation of process inventories. PS-09 aims to assure a functional blowdown system are available at all times that the associated plant is operational so escalation of spill events can be prevented by the depressurisation of process inventories via release to flare when initiated rather than to the marine environment.	inspections and maintenance of system.	undertaken and compliance is maintained outweigh the costs of personnel time
NV-CM-62	Production operating procedures	Procedures to ensure production operations are within the operating envelope to maintain the integrity of the subsea infrastructure. Operating within envelopes reduces unplanned hydrocarbon release risk.	Costs associated with personnel time in writing, reviewing and implementing the procedures.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-64	Testing of ESD and blowdown systems	ESD and blowdown systems are function tested in accordance with: + PS-06 ESD and Blowdown: Emergency Shutdown	Personnel costs associated with testing and ensuring testing takes place.	**Adopted** – benefits of ensuring testing of ESD and blowdown systems occurs outweighs the costs of personnel time.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Valves (ESDVs) (NV-00-RG-10053.06) + PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). ESD and blowdown systems will detect abnormal process conditions and alert the operators to execute preventative and mitigative actions on crude hydrocarbon containing equipment (including subsea system). Functioning and tested ESD and blowdown systems ultimately prevent / minimise release volumes and initiate blowdown and shutdown on hydrocarbon containing equipment during abnormal process, limiting any release to the environment.		
NV-CM-66	Oil pollution emergency plan (OPEP)	Implements response plan to deal with an unplanned hydrocarbon spills quickly and efficiently in order to reduce impacts to the marine environment.	Personnel and administrative costs associated with preparing documents, ongoing management (spill response exercises) and implementation of OPEP.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-67	Incident Response Plan detailing the requirements for preparedness and response to emergencies and crises to protect people and the environment.	Provides detail to ensure the ESD system is activated quickly and efficiently if it has not automatically activated, to reduce the extent of impacts to the marine environment.	Administrative costs of preparing documents.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-68	Santos' decommissioning framework implemented prior to EOFL (refer to **Section 8.8**).	Ensures an appropriate level of planning for the eventual permanent plug and abandonment of Van Gogh and Coniston Novara wells and removal of property. Ensures Santos has plans in place to meet its regulatory obligation to remove property in accordance with the requirements of s.572 of the OPGGS Act.	Organisational costs to prepare plans.	**Adopted** - Benefits considered to outweigh costs. Regulatory obligation to remove property.
Additional control measures				
N/A	Real time leak detection using pressure and temperature instrumentation	Would allow detection of a leak and subsequent environmental release to be detected immediately with activation of ESD.	Pressure and temperature instrumentation are ineffective at detecting fugitive leaks and emissions in the subsea environment.	**Rejected** -Control is not effective at detecting fugitive leaks and emissions in the subsea environment.
N/A	Continuous ROV monitoring of subsea system	Ensures that leaks are detected quickly during visual inspection of the valves. Would reduce the time a small leak is undetected, reducing the volume released to the environment.	The cost for 24-hour monitoring in field including vessel hire is estimated at approximately $200K/day and only effective during periods of good weather.	**Rejected** – Large cost associated deemed grossly disproportionate compared to risk.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
N/A	Scheduled designated monitoring flights for leak detection	Dedicated helicopter flights solely for leak monitoring over the NV subsea infrastructure can identify small leaks from the subsea system on the sea surface through oil sheen, initiating investigation into the leak source and ultimately reducing the duration of leak.	High cost involved with scheduling flights specifically for leak detection and training of personnel. Relies heavily on suitable weather to allow for visual observation from the helicopter to notice a sheen on the surface.	**Reject** – Costs which grossly outweigh the environmental benefit when leaks may be picked up opportunistically during routine crew change helicopter flights.
N/A	Testing of ESD and blowdown systems at greater frequency than that detailed by PSAPs	Little environmental benefit. PSAP approach determines function testing and inspection frequency. Testing frequency may be greater based on a risk based approach (e.g. inspections or analysis results) which indicate further testing and inspection is required. Unwarranted testing is determined to provide little to no integrity assurance benefits.	Costs associated with testing of ESD and blowdown systems at greater frequencies. Unwarranted testing also presents unwarranted safety (e.g. failure induced by excessive function testing) and environmental risks.	**Reject** – Costs which grossly outweigh the environmental benefit. Unwarranted function testing and inspection greater than that of a risk based PSAP risk based approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit
N/A	Low pressure alarm on subsea systems	A low pressure alarm has the ability to notify the operator of pressure drops in the subsea system. Investigation can then commence to determine whether a subsea leak is occurring.	Cost and personnel effort in installing alarm Feasibility issues as pressure alarm would have to be lower than the hydrostatic pressure at the seabed	**Reject** – The low pressure alarm would have to be lower than the hydrostatic pressure at the seabed. The alarm would be ineffective as it would not be able to detect a leak, based on geometry and

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
				volume of piping network.
N/A	Protection and burying to protect from external impacts	Protection and burying of the flowlines and subsea infrastructure will reduce the risk of dropped objects impact.	Large cost and seabed disturbance associated with burying and protection. Burying the infrastructure also causes technical inspection and maintenance activity issues.	**Rejected** – Large cost associated with burying and protecting is disproportionate compared to the risk. May also cause operational issues.
N/A	Rock dump of flowline to protect from external impacts	Rock dump of flowline will reduce the risk of dropped objects impact.	Large cost and seabed disturbance associated with rock dump. Burying the infrastructure also causes technical inspection and maintenance activity issues.	**Rejected** – Large cost associated with rock dump disproportionate compared to risk. May also cause operational issues.
N/A	Response equipment (e.g. booms) on location, ready to respond to a loss of hydrocarbons	May allow for quicker response to a spill as resources will be within proximity.	Large costs associated with a dedicated resource on location.	**Rejected** – Large cost associated with dedicated resources on location deemed grossly disproportionate compared to risk

7.7.4 Environmental Impact Assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.6**

7.7.4.1 Identification of Hotspots for Consequence Analysis

As described in **Section 7.5.6**, all HEVs within the EMBA (low exposure value) are listed in **Table 7-25** below. The values and sensitivities associated with these HEVs have been described in **Appendix D1.** Further to this **Table 7-25** filters the HEV to identify the hotspots where they meet the criteria described in **Section 7.5.6**

Table 7-25: Identified High Environmental Value and Hotspot Receptors

Receptor	HEV Value	Exposure Value*	Hotspot

		Low	Moderate	High	
Dampier Archipelago	3	✓			
Northern Islands Coast	5	✓			
Montebello Islands	3	✓	✓	✓	
Barrow Island	3	✓	✓		
Thevenard Islands	5	✓	✓		
Southern Islands Coast	5	✓			
Muiron Islands	2	✓	✓	✓	✓
Ningaloo Coast North	2	✓	✓	✓	✓
Ningaloo Coast South	3	✓			
Carnarvon - Inner Shark Bay	2	✓			
Outer Shark Bay Coast	3	✓			
Zuytdorp Cliffs - Kalbarri	3	✓			
Kalbarri - Geraldton	3	✓			
Geraldton - Jurien Bay	3	✓			
Abrolhos Islands Wallabi Group	2	✓			
Abrolhos Islands Pelsaert Group	2	✓			
Barrow-Montebello Surrounds	3	✓			
Montebello AMP	4	✓	✓		
Outer Ningaloo Coast North	1	✓	✓		
Outer NW Ningaloo	3	✓	✓	✓	✓
Offshore Ningaloo	4	✓	✓	✓	
Rankin Bank	5	✓			
Outer Abrolhos Islands - Shoals	3	✓			
Abrolhos Islands Easter Group	2	✓			
Dampier AMP	4	✓			
Shark Bay AMP	4	✓			
Eighty Mile Beach AMP	4	✓			
Rowley Shoals surrounds	4	✓			
Abrolhos West	2	✓			
Offshore Abrolhos NW	4	✓			
Nearshore Abrolhos	4	✓			

Offshore Abrolhos - Perth North	4	✓			

* greater than 5% probability of contact

This process identified the following hotspots:

+ Muiron Islands
+ Ningaloo Coast North; and
+ Outer NW Ningaloo.

Table 7-20 provides a simplified summary of the consequence assessment results for each of the Hotspot areas. The consequence assessment was based on predicted contact and concentration of surface oil, accumulated oil, entrained hydrocarbon and dissolved hydrocarbons. For each Hotspot area the consequence to the key values were assessed using the methodology described in **Section 7.5.6**.

The following individual scenarios (as defined in **Section 7.7.1**) leading to a subsea release of hydrocarbons from the subsea equipment have been risk assessed in the below sections:

+ Subsea release of Van Gogh crude blend from a subsea system rupture; and
+ Subsea release of Van Gogh crude blend from a subsea system leak.

7.7.4.2 Subsea release of Van Gogh crude blend from a subsea system rupture

<table>
<tr><td>Receptors</td><td>Threatened, migratory, and local fauna
Protected areas
Physical environment and habitats
Socio-economic receptors</td></tr>
<tr><td>Consequence</td><td>IV - Major</td></tr>
<tr><td colspan="2">Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in Table 7-15 and potential impacts to receptors from the moderate exposure thresholds are described in Table 7-16.
<u>Threatened, Migratory, and Local Fauna</u>
With high winds (10 m/s), significantly higher rates of dispersion are predicted, with approximately 65% of the released oil dispersed into the water column after 24 hours (GHD, 2019). A net result of weathering the Van Gogh crude blend is effectively losing the remaining volatile fraction of the oil and leaving a further degraded, waxier and heavier crude oil in any spill incident (Intertek, 2018), which may persist for some time. The potential sensitive receptors in the surrounding areas of the release will include fish, marine mammals, marine reptiles and seabirds at the sea surface, as discussed Section 3.2.3 which may come into contact with Van Gogh crude blend leading to skin or eye irritation or oiling of the birds feathers (as described in Table 7-16). It is expected that a subsea Van Gogh crude blend release from the subsea system has the potential to result in an insignificant disruption to the breeding cycle for marine mammals.
The humpback whale (migration and resting) and pygmy blue (distribution, migration and foraging), BIAs overlap the moderate exposure value EMBA. An unplanned release of Van Gogh crude is not expected to interfere with their migration activity. There is the potential for behavioural disruption to the local population as individuals traverse the release.
Deteriorating water quality / chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (Table 3-8). Habitat modification, degradation and disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Given the location of the release, and volume of potential hydrocarbon release there is the potential for</td></tr>
</table>

modification to or a decrease in the availability of quality habitat (shorelines/subsurface), particularly given the volumes of accumulated hydrocarbons (maximum volume of hydrocarbon accumulation is at Ningaloo Coast North – 647 tonnes) and persistence of crude. Shoreline accumulation may present a major disruption to shoreline individuals (as described in **Table 7-16**). Volumes of accumulated hydrocarbon may result in a major reduction in area available for seabirds and/or turtles species. The quality of habitat (shorelines/subsurface) may be reduced for a period, with recovery over decades.

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves states that DPaW should 'ensure that important seabird and shorebird breeding and feeding areas are not significantly affected by human activities'. The potential impacts of a hydrocarbon release on seabird breeding and feeding areas are discussed in **Table 7-16**. Impacts in relation to human activities from responding to a spill are described in **Section 6.8**.

<u>Physical Environment and Habitats</u>

In the event of Van Gogh crude blend release, hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a long-term decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. The quality of habitat may be reduced for a significant period with recovery over decades.

As described above, accumulated hydrocarbons on shorelines could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill. Beaches on the Ningaloo Coast are important for green turtles, and to a lesser extent hawksbills turtles, while Muiron Islands has a regionally important nesting site for loggerhead turtles. Impacts to turtles could occur from surface hydrocarbons if oil accumulates on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. The quality of habitat available to the turtles will be reduced, with recovery over a decade.

<u>Protected Areas</u>

The moderate exposure value EMBA intersects several protected areas and AMPs and marine management areas (impacts discussed in **Table 7-16** and AMP details presented in **Section 3.2**). Combined, these areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described in **Table 7-16** and impact on the values of these reserves could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves.

<u>Socio-economic Receptors</u>

There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. A major spill would result in the establishment of a safety exclusion zone around the affected area. A temporary prohibition on fishing activities for a period, and subsequent potential for economic impacts to those affected. Hydrocarbon may also foul fishing equipment which will require cleaning or replacement.

Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Fish have a high capacity to metabolise these hydrocarbons, while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). 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 (Yender et al. 2002).

Heritage values are not predicted to be impacted by surface oil although in the short-term there would be an impact on the aesthetic value of the area.

There are oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A Van Gogh crude blend subsea release from a well leak has the potential to disrupt these activities if contacted at moderate or high surface exposure values, with associated economic impact, albeit on a temporary basis.

Tourism could be affected by spilled Van Gogh crude blend, either from reduced water quality/shoreline oiling preventing recreational activities or reducing aesthetic appeal or from impacts

to habitats and marine fauna. marine nature-based tourist activities, resulting in a loss of revenue for operators. Indigenous users may be impacted if a land-based response is required. However, consultation will help manage activities such that potential impacts are reduced to acceptable levels. Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon release were to occur as fish may be 'tainted' as described above. On the basis of the above assessments, a Van Gogh crude blend subsea release from the subsea system, has the potential to impact an array of receptors. Given the extent, the worst-case consequence is considered to be *Major (IV).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of Van Gogh crude blend from a subsea system rupture due to internal influence or external impact has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. External impacts to subsea systems have not occurred within Santos and controls are in place which limit vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the subsea infrastructure is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of Van Gogh crude blend from a subsea system rupture resulting in a *Major (IV)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Low**

7.7.4.3 Subsea release of Van Gogh crude blend from subsea system leak – detected within 1 day

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values are described in **Table 7-16.** The size of release from a subsea system / pipeline leak is significantly smaller than the credible subsea system worst-case loss (Van Gogh crude blend from a subsea system rupture), which has been modelled (**Section 7.7.2.2**) and risk assessed (**Section 7.7.4.2**). Given the size of the release (150 m^3) a subsea release of Van Gogh crude blend from subsea system leak (detected within 1 day) will impact local marine fauna in the immediate site of release and relate to short term behavioural change. Impacts to water quality will be localised but detectable and occur for a short duration whilst the release disperses. Rapid recovery is expected. A subsea release of Van Gogh crude blend from subsea system leak (detected within 1 day) has the potential to insignificantly impact local marine fauna and physical environments and habitats. Given the spill size, the worst-case consequence is considered to be *Minor (II).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of Van Gogh crude blend from a subsea system leak (detected within 1 day) due to internal influence or external impact has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the subsea infrastructure is maintained.	

In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of Van Gogh crude blend from a subsea system leak (detected within 1 day) resulting in a *Minor (II)* consequence is considered to be *Remote*	
Residual Risk	The residual risk associated with this event is **Low**

7.7.4.4 Subsea release of Van Gogh crude blend from subsea system leak - potentially undetected for up to 365 days

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values are described in **Table 7-16.** The size of release from a subsea system / pipeline leak is significantly smaller than the credible subsea system worst-case loss (Van Gogh crude blend from a subsea system rupture), which has been modelled (**Section 7.7.2.2**) and risk assessed (**Section 7.7.4.2**). Given the size of the release a subsea release of Van Gogh crude blend from subsea system leak (potentially undetected for up to 365 days) will impact local marine fauna in the immediate site of release and relate to short term behavioural change. Impacts to water quality will be localised but detectable and occur for a short duration whilst the release disperses. Van Gogh crude blend may also emulsify and be contained within the water column for a period whilst it weathers and disperse, Given the minor volumes significant emulsification is not anticipated and will be within the extent of the worst-case loss (Van Gogh crude blend from a subsea system rupture). Rapid recovery is expected. A subsea release of Van Gogh crude blend from subsea system leak (potentially undetected for up to 365 days) has the potential to insignificantly impact local marine fauna and physical environments and habitats. Given the spill size and the potential duration of up to 365 days, the worst-case consequence is considered to be *Minor (II).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of Van Gogh crude blend from a subsea system leak (potentially undetected for up to 365 days) due to internal influence has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely to happen in the long term. Santos has applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the subsea infrastructure is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of Van Gogh crude blend from a subsea system leak (potentially undetected for up to 365 days) resulting in a *Minor II)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Low**

7.7.5 Demonstration of ALARP

External Impact Controls

The location and depth (340-400 m) of the operational area reduces the likelihood of external vessels impacting the subsea production system. The depth of water is too deep for vessel anchoring, including tankers. Drilling activities are not proposed under this EP and therefore any rig anchoring required in the Operational Area will be managed under a separate EP. While trawling could potentially be used by the North West Slope Trawl Fishery, the Operational Area has not been historically fished with effort restricted to east of the Montebello/ Barrow/ Lowendal Islands. Consultation with the fishing industry is included in **Section 4** of this EP.

Vessels undertaking IMMR activities are required to have dynamic positioning allowing subsea inspection activities to be performed without anchoring and eliminating the risk of anchor dragging, impacting the subsea system. The use redundancy in the positioning system provides assurance that inspection activities will not damage subsea infrastructure through dragging objects (e.g. ROVs).

The key dropped object prevention controls preventing dropped objects onto subsea infrastructure is the provision of load alarms on FPSO cranes. Lifting procedures and inspection/testing requirements for cranes and lifting equipment on the FPSO and vessels reduces the risk of dropped objects onto the subsea production system. Transferring of equipment materials and waste between support vessels and the FPSO cannot be eliminated from the operational area and thus the risk of dropped objects cannot be removed.

Set excursion limits with the DTM System Daily Monitoring and Immediate Actions Procedure (NV-22-IU-10001) allow for protection of risers from FPSO excursion off location. Excursion is monitored, and an alarm will alert the operator should excursion of the FPSO exceed limits (DTM excursions ≥ 25m). The DTM System Daily Monitoring and Immediate Actions Procedure (NV-22-IU-10001) includes the actions required to be initiated to bring the FPSO within excursion limits. Limits of excursion are monitored and have been set so no risers can be impacted, this is considered ALARP as it eliminates impact. No other reasonable controls to limit excursion or alert, should it occur have been identified.

The primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005). This system responds to both automatic and manual activation, with automatic activation triggered by abnormal process conditions, such as pressure drop across the subsea production system. The emergency shutdown system functionality and reliability is maintained through regular testing of the shutdown systems and the subsea valves. The regular testing and maintenance of the emergency shutdown and blowdown systems are managed through Performance Standard Assurance Plans (PSAPs), which provide the work instructions and performance criteria to test and service the shutdown and blowdown systems. The relevant PSAPs contain specific performance criteria as detailed below:

+ PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06). The performance criteria specified in PS-06 includes:
  - ESDV location, ESDV actuation requirements, Valve travel timings, acceptable leakage rates for riser ESDVs
+ PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) for the Well and Tree Valves except for the water injection wells. The performance criteria specified in PS-07 includes:
  - Master valve and wing valve testing and leak rate requirements, Master and Wing valve closure requirements, hydraulic system dump capabilities
+ PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). The performance criteria for Safety instrumented Systems in PS-08 includes:
  - The Safety Integrated system shall initiate shutdown and blowdown of the process during abnormal process conditions in accordance with the Cause and Effects Diagrams and alarm and trip schedule, ESD pushbutton locations, Reliability/availability achievements through redundancy, backup power, regular function testing and self-diagnostic capability.

The relevant PSAPs are listed as control measures with relevant performance standards in **Table 8-2**.

The maintenance and regular testing of the ESD and blowdown systems and the subsea valves managed through the PSAPs ensures a functional, available, reliable, survivable independent control ensuring the emergency shutdown and blowdown functionality, resulting in near-instantaneous shut in following loss of pressure and is considered to reduce the spill volume to ALARP for a major leak/rupture scenario.

A functioning and tested ESD and blowdown system in accordance with the relevant PSAPs is designed retain liquid in on board and blowdown gas rather than discharge to environment in the event of an emergency situation. Other means of mitigating an emergency situation (such as over pressure) may be to discharge or release hydrocarbon to the marine environment. The NV ESD and blowdown system is therefore considered ALARP

Function testing and inspection frequency and intervals within Santos PSAPs are based on a combination of:

+ Industry recommendations / standards
+ Manufacturers recommendations
+ Statutory obligations
+ Integrity risk (based on previous inspections or other triggers)

Unwarranted function testing and inspection greater than that of a PSAP approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit.

A PSAP deviation process is detailed in the Santos Permitted Operations Procedure (QE-00-IG-00183), which provides allowance for deferral of PSAP assurance activities on a completion of a risk assessment process, which shows safe operations can continue and integrity can be maintained. Further details on this process is provided in **Section 8.3.1.1.**

<u>Internal influence controls</u>

The integrity of the subsea production system is maintained through planned inspection, monitoring and testing of its components ensuring that the system operates within its design requirements and there is no unacceptable degradation of the system (e.g. materials, or ESD valve shutdown time/leakage etc.). Inspection of subsea infrastructure made in accordance with the Inspection Monitoring and Maintenance Plan (IMM Plan) and Santos Performance Standards (PS) / Performance Standard Assurance Plans (PSAPs) will ensure subsea infrastructure integrity is maintained.

IMMR includes an annual GVI of hydrocarbon containing subsea systems and structures. IMMR is in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007). which provides inspection frequencies, scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment. IMMR campaigns may also opportunistically identify small leaks during inspections, otherwise undetected through the NV control room or production data review, through the annual GVI. Hence, the annual GVI subsea leak inspection may be completed in a number of campaigns within the calendar year.

Frequencies for IMMR is based on a schedule set within Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) (see **Table 2-9**) and includes nominal inspection frequencies and a commitment to an annual GVI inspection of hydrocarbon containing subsea systems and structures. The nominal IMMR frequencies and intervals may also be increased on the basis of risk (**Section 2.13.1**). Risk assessments are undertaken following physical events, integrity assessments or other triggers (e.g. inspections or analysis results). Based on these risk assessments additional GVI inspections may be performed. Conducting IMMR when not required presents unwarranted risks (e.g. risks associated with vessel use, marine growth removal) and additional costs which grossly outweigh the environmental benefit.

A number of controls in addition to the IMMR were investigated to detect small leaks:

+ Continuous use of the ROV for monitoring of leaks.
+ Realtime monitoring of the wells for small leaks using pressure and temperature instrumentation.
+ Scheduling specific flights for leak detection through identification of sheen.

As detailed in **Table 7-24**, these controls either are ineffective or costs associated grossly outweigh the environmental benefits. As such, the use of IMMR to mitigate and detect small leaks, with an annual frequency set for GVI of the hydrocarbon containing elements of the subsea production system, and the ability to increase frequency based on output of a risk assessment approach has been determined ALARP.

Burying the subsea infrastructure under the seabed and protecting the subsea infrastructure with mattresses was investigated as a mitigation against dropped objects and anchor drag impacts. However, the large cost associated, and additional seabed disturbance impacts were determined to be disproportionate compared to risk. Operational issues may also arise when inspection and maintenance is required.

Placement of response equipment (e.g. booms) on location (the FPSO or support vessels), ready to respond to a loss of hydrocarbons event was investigated however the cost of upkeep and the space required for the equipment was determined to be grossly disproportionate to the benefits.

The ongoing general inspection and maintenance regime that is completed in accordance with the NOPSEMA-accepted WOMP and Santos procedures, ensures that property is maintained in good condition and repair until the point in time when the property is removed from the title.

It is through the development and eventual implementation of the Decommissioning Plan that Santos will meet its obligations under s. 572 (3) of the OPGGS Act ‘to remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations’.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos have where practicable, adopted all reasonable controls for reducing the risk.

With the above control measures in place, Santos deem that the activity risk from an unplanned release of Van Gogh crude blend from the subsea system is ALARP.

7.7.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Residual risk is ranked as Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with OPGGS Regulations including Safety Case and WOMP. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities including the Montebello Australian Marine Park, the Barrow Island Marine Park Management Area, Montebello Marine Park, Muiron Island Marine Management Area, Ningaloo Australian Marine Park.; and Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015)

	+ Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016) + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016) + Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

The likelihood of a release of Van Gogh crude blend from a subsea system is extremely low (remote) when considering industry statistics on the event, Santos statistics and the preventative controls in place. Additional industry standard and activity-specific control measures to reduce the chance of the event occurring (and minimise impacts) have also been implemented including (but not limited to) inspection monitoring and maintenance of subsea infrastructure, corrosion and subsea infrastructure integrity management, testing and maintenance of emergency shutdown systems, charting of subsea infrastructure and spill response (NV OPEP).

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect of the NV Operations

In accordance with Santos risk assessment process, the residual risk is considered to be Low and ALARP. The proposed control measures will reduce the risk of impacts from a subsea Van Gogh crude blend from a subsea system rupture to a level that is considered acceptable.

7.8 Surface Release of Hydrocarbon (Van Gough crude blend) to the Marine Environment

7.8.1 Description of Event

Event

Van Gogh crude blend can be released to the marine environment at the sea surface through four scenarios, inclusive of vessel collision, process upset, equipment failure and corrosion. The following scenarios are credible:

No.	Scenario	Maximum credible volume
1	Surface release of Van Gogh crude blend from the FPSO or offtake tanker as a result of an external impact (vessel collision) which ruptures a crude tank	8,630 m^3 over 1 hour
2	Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment as a result of an external impact (vessel collision) or internal influence (e.g. integrity loss of equipment)	1,286 m^3 over 15 minutes
3	Surface release of Van Gogh crude blend from a rupture or leak in the topside process equipment as a result of external impact (dropped object) or internal influence (e.g. integrity loss of equipment)	700 m^3 over 1 hour.
4	Surface release of Van Gogh crude blend from process upset on FPSO (liquid carry-over to flare)	35 m^3 over 5 minutes

1. Surface release of Van Gogh crude blend from the FPSO or offtake tanker as a result of an external impact (vessel collision) which ruptures a crude tank

A collision event may occur between the following:

- Offtake tanker and FPSO
- Vessel (third party or Santos support or project vessel) and FPSO
- Offtake tanker and vessel (third party or Santos support or project vessel)

The worst case release is 50% volume of the largest tank.

The FPSO have cargo tanks which are double-sided design and provide two physical barriers between oil and the marine environment for side impact. The maximum storage volume for FPSO is 86,600 m^3. However, the maximum volume of a single tank, protected by double sides, is approximately 17,200 m^3. As the FPSO has cargo tanks which are double-sided with multiple barriers are in place to both prevent and mitigate any loss of containment, it is considered conservative to use the AMSA Guidelines for non-major collisions, which is 50% volume of the largest tank protected by double sides. The maximum credible release is therefore 8,630 m^3 over 1 hour.

The offtake tankers have cargo tanks which are double-sided design and provides two physical barriers between oil and the marine environment for side impact. Crude offtake tanker cargo tanks are smaller than the FPS cargo tanks, and any release would be smaller than the FPSO release detailed above. A spill from the offtake tanker is only within the scope of the EP whilst the tanker is connected and carrying out a crude offtake.

	2. Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment as a result of an external impact (vessel collision) or internal influence (e.g. integrity loss of equipment) This scenario is credible under the assumption of multiple and simultaneous failures of controls in place. Vessel impact, operator error, loss of vessel positioning, or loss of integrity causing loss of containment from offtake equipment is deemed credible. Major loss of containment would be detected and result in almost instantaneous ESD. The maximum credible spill is calculated based on a transfer rate (5,000 m^3/hr) x 15 minutes of flow (continuous supervision) plus the volume in the offtake hose (36 m^3). The maximum credible release is therefore 1,286 m^3 over 15 minutes. 3. Surface release of Van Gogh crude blend from a rupture or leak in the topside process equipment as a result of external impact (dropped object) or internal influence (e.g. integrity loss of equipment) Major loss of containment from topside process equipment would be detected resulting in almost instantaneous emergency shutdown as the FPSO is permanently manned. As failures of multiple barriers have been assumed for conservatism, it may take up to 1 hour before manual detection and isolation. Multiple failures of Emergency Shutdown valves (ESD) resulting in total loss of topsides containment is not considered credible, therefore the total volume of single largest isolatable inventory has been used. As the FPSO is continuously manned it is considered conservative to use the AMSA Guidelines. The maximum credible spill is therefore calculated based on 100% maximum flow (production) rate for 1 hour (418 m^3) plus the volume of oil in the topsides (282 m^3). The maximum credible release is therefore 700 m^3 over 1 hour. 4. Surface release of Van Gogh crude blend from process upset on FPSO (liquid carry-over to flare) As the FPSO and process is continuously manned, and there are a number of barriers in place, it is considered conservative to use a 5 minute response time to liquid spilling from flare. The maximum credible spill is therefore calculated based on 100% maximum flow (production) rate of 10,016 m^3/day for 5 minutes, which is a conservative estimate based on almost immediate detection from the NV FPSO control room monitoring . The maximum credible release is therefore 35 m^3 over 5 minutes. The maximum release of Van Gogh crude blend to the marine environment at the sea surface is 8,630 m^3 over 1 hour (Scenario 1).
Extent	Stochastic modelling determined that the hydrocarbon extent based on moderate exposure values (**Section 7.5.5**) is: + Surface oil at moderate exposure value may occur out to 250 km from the release location. + Dissolved hydrocarbons are highly local to the release. + Entrained hydrocarbon may occur out to 550 km from the release location. + Shoreline accumulation at a number of receptors the furthest being Zuytdorp Cliffs – Kalbarri, approximately 800 km from the release location.
Duration	Instantaneous through the rupture.

7.8.2 Nature and Scale of Impacts

Hydrocarbon spills will cause a decline in water quality and may cause chemical (e.g. toxic) and physical impacts to marine species (e.g. coating of emergent habitats, oiling of wildlife at sea surface). The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (i.e. extent, duration) and sensitivity of the receptor.

Potential receptors: Shallow benthic, intertidal and shoreline habitats; plankton; invertebrates; fish; marine mammals; marine reptiles; birds (seabirds and shorebirds); fisheries; oil and gas industry; tourism; KEFs; and State and Commonwealth marine reserves and Australian Marine Parks.

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are further described in **Table 7-16.**

7.8.2.1 Hydrocarbon Weathering Behaviour

Refer **Section 7.6.2**.

7.8.2.2 Spill Modelling Results

To determine the spatial extent of impacts from a potential surface of Van Gogh crude blend and the dispersion characteristics over time, modelling was completed by GHD (GHD, 2019). A volume of 8,630 m^3 released over 1 hour at the sea surface was modelled at the FPSO location.

Modelling results have been provided for each of the four hydrocarbon fates: shoreline accumulation; surface; dissolved and entrained.

The modelling results are presented for the fate of hydrocarbon at the exposure values defined in **Section 7.5.5**. **Table 7-26** has been provided for the purposes of risk evaluation, displaying the following parameters:

+ Minimum time to contact from moderate and high exposure value;
+ Maximum hydrocarbon concentration from high exposure value;
+ Maximum hydrocarbon accumulation on shoreline from moderate and high exposure value; and
+ Length of shoreline oiled.

Further parameters required to inform spill response strategies are described further in the NV Operations OPEP (TV-00-RI-00003.02).

Surface Oil

Low

Stochastic modelling determined that surface oil at concentrations equal to or greater than 1 g/m^2 could extend up to 450 km from the release location. HEVs with the potential to be contacted at the low exposure value are:

+ Offshore Ningaloo;
+ Outer NW Ningaloo;
+ Outer Ningaloo Coast North;
+ Ningaloo Coast North;
+ Muiron Islands;
+ Ningaloo Coast South;
+ Montebello AMP; and
+ Southern Islands Coast.

Moderate and High

Stochastic modelling determined that surface oil at moderate exposure value of 10 g/m^2 may occur out to 250 km from the release location. Surface oil at the high exposure value of 50 g/m^2 may occur out to 230 km from the release location. HEVs with the potential to be contacted at the moderate and high exposure values are:

+ Offshore Ningaloo;
+ Outer NW Ningaloo;
+ Outer Ningaloo Coast North;
+ Ningaloo Coast North; and
+ Muiron Islands.

<u>Dissolved Hydrocarbons</u>

Low

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 10 ppb may occur out to 150 km from the release location.

Moderate and High

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 50 ppb may occur out to and may contact one HEVs (Offshore Ningaloo). No HEVs are contacted at the high exposure value.

<u>Entrained hydrocarbon</u>

Low

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 10 ppb may occur out to 900 km from the release location.

Moderate and High

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 100 ppb may occur out to 550 km from the release location. At the moderate exposure value of 100 ppb there is greater than 1% probability of entrained hydrocarbon reaching five HEVs: Muiron Islands, Ningaloo Coast North, Outer Ningaloo Coast North, Offshore Ningaloo and Outer NW Ningaloo. No HEVs are contacted at the high exposure value.

<u>Shoreline Accumulation</u>

Low

Shoreline accumulation above the low exposure value may occur at 10 HEVs with the furthest from the release location being Zuytdorp Cliffs – Kalbarri, approximately 800 km from the release location.

Moderate

Shoreline accumulation above the moderate exposure value of 100 g/m^2 may occur at seven HEVs:

+ Montebello Islands;
+ Barrow Island;
+ Muiron Islands;
+ Ningaloo Coast North;
+ Ningaloo Coast South;

- Outer Shark Bay Coast; and
- Zuytdorp Cliffs – Kalbarri.

The furthest being Zuytdorp Cliffs – Kalbarri, approximately 800 km from the release location.

High

Shoreline accumulation above the high exposure value of 1,000 g/m^2 may occur at three HEVs: Muiron Islands, Ningaloo Coast North and Ningaloo Coast South.

Santos

Table 7-26: Summary of Hydrocarbon Contact with Receptors: 8,629 m^3 Surface Crude Release

Receptor	Receptor Type	Minimum time to contact (days)							Maximum hydrocarbon concentration							Maximum oil ashore (tonnes)	Maximum length of oiled shoreline (km)
		Moderate exposure values				High exposure values			Moderate exposure values				High exposure values				
		Shoreline accumulation 100 g/m^2	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50 g/m^2)	Shoreline accumulation (100 gm^2)	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (50 g/m^2)	Shoreline accumulation (100 g/m^2)	Shoreline accumulation (100 g/m^2)
Montebello Islands	Emergent	16	NC	NC	NC	NC	NC	NC	6	NC	NC	NC	NC	NC	NC	6	11
Barrow Island	Emergent	12	NC	NC	NC	NC	NC	NC	10	NC	NC	NC	NC	NC	NC	10	14
Southern Islands Coast	Emergent	NC	NC	NC	3	NC	NC	NC	NC	NC	NC	112	NC	NC	NC	NC	NC
Muiron Islands	Emergent	2	2	NC	2	NC	2	2	308	105	NC	709	NC	304	130	308	11
Ningaloo Coast North	Emergent	2	1	NC	2	NC	2	1	1254	573	NC	2,195	NC	1,251	585	1,254	133
Ningaloo Coast South	Emergent	5	NC	NC	6	NC	5	NC	259	NC	NC	142.7	NC	185	NC	259	127
Montebello AMP	Submerged	NA	NA	NC	6	NC	NC	NC	NA	NA	NC	236	NC	NC	NC	NA	NA
Outer Ningaloo Coast North	Intertidal	NC	1	NC	1	NC	NC	<1	NC	1,810	NC	2,251	NC	NC	1,804	NC	NC

Shark Bay AMP	Submerged	NA	NA	NC	24.4	NC	NC	NC	NA	NC	NC	106	NC	NA	NC	NA	NA
Outer NW Ningaloo	Submerged	NA	<1	NC	<1	NC	NC	<1	NA	1,955	NC	6,301	NC	NA	1,954	NA	NA
Offshore Ningaloo	Submerged	NA	<1	<1	<1	NC	NC	<1	NA	3,884	94	4,659	NC	NA	3,886	NA	NA
Offshore Abrolhos NW	Submerged	NA	NC	NC	24	NC	NC	NC	NA	NC	NC	115	NC	NA	NC	NA	NA
Outer Shark Bay Coast	Emergent	17	NC	NC	NC	NC	NC	NC	19	NC	NC	NC	NC	NC	NC	19	34
Zuytdorp Cliffs - Kalbarri	Emergent	25	NC	NC	NC	NC	NC	NC	<1	NC	NC	NC	NC	NC	NC	1	3

NC = no contact

NA = not applicable

7.8.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-09]

The control measures considered for this event are shown in **Table 7-27**. EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Selection of oil spill response strategies and associated EPOs, control measures and EPSs, including those required to maintain preparedness and for response, are detailed within the OPEP. The OPEP contains an evaluation of oil spill preparedness arrangements to demonstrate that oil spills will be mitigated to ALARP.

Table 7-27: Control Measures Evaluation for a Surface Release of Van Gogh Crude Blend to the Marine Environment

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
NV-CM-76	Hull integrity	FPSO and offtake tanker hull is double-sided design providing two physical barriers between cargo tanks and the marine environment for side impact, reducing potential for release in the event of collision.	FPSO and offtake tanker is double-sided design and control is already in place. Costs involved with maintaining hull integrity.	**Adopted** - The benefits to safety and the environment, (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-77	Berthing and Terminal Handbook (TV-22-IG-00067)	The Berthing and Terminal Handbook (TV-22-IG-00067) provides details for safe approach (e.g. daylight hours, speed, pilot accreditation) and berthing of the offtake tanker to the FPSO, reducing potential for release in the event of collision. The Berthing and Terminal Handbook also defines parameters (e.g. metocean) for offtake to occur and reducing risk of release events.	Organisational costs associated with ensuring procedures are in place, up to date and implemented.	**Adopted** – benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		Offtake tankers are subject to acceptance criteria stated in the Berthing and Terminal Handbook, which is used to assess the suitability of the proposed offtake tanker to comply with the equipment and operational procedures developed to ensure safe offtake. This process also vets offtake tankers against the Oil Companies International Marine Forum (OCIMF) guidelines		
NV-CM-78	Offtake Operations and Pilotage Procedure (NV-91-IG-10010.03)	The Offtake Operations and Pilotage Procedure (NV-91-IG-10010.03) includes the following offtake requirements to prevent a release during crude transfers: + Requirement that the floating hose is of double carcass structure and fitted with a quick release dry-break coupling on the connection between the floating hose and the hose reel. + Completion of a Pre-berthing toolbox talk before each offtake which includes a check of the key controls, functioning equipment and	Organisational costs associated with ensuring procedure is in place, up to date and implemented.	**Adopted** – benefits of ensuring procedure is followed and measures implemented outweigh the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		communication which mitigate against vessel to vessel interaction and loss during crude transfers + Completion of the Offtake Operations Checklist which includes a check that the key equipment / communications mitigating a release to the environment is in place, this includes the following checks: + Floating hose reel has been tested + Spill response kits are on location + Floating hose O ring inspected + Hose connected + Offtake operations communications checked + All scupper plugs are in place		
NV-CM-64	Testing of ESD and blowdown systems	ESD and blowdown systems are function tested in accordance with: + PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06)	Organisational costs associated with testing and ensuring testing takes place.	**Adopted** – benefits of ensuring testing of ESD and blowdown systems occurs outweighs the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		+ PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). ESD and blowdown systems testing will detect abnormal process conditions and alert the operators and execute preventative and mitigative actions on hydrocarbon containing equipment. The flare is monitored from NV control systems. A functioning and tested ESD control system is designed to prevent flare carryover and retain liquid in on board and blowdown gas rather than discharge to environment.		
NV-CM-61	Inspection of hydrocarbon containing equipment	FPSO hydrocarbon containing equipment meets inspection criteria and frequency as specified in PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08). Equipment includes:	Negligible organisational costs associated with inspections.	**Adopted** – benefits of ensuring inspections are undertaken and compliance is maintained outweigh the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		+ Topsides & offloading pressure containing equipment + Pumps + Engine Room and Cargo Equipment Inspection of topsides hydrocarbon containing equipment assures hydrocarbon pressure containment measures are in place and functioning to prevent the uncontrolled release of hydrocarbons from topsides.		
NV-CM-65	Blowdown and flare system	Flare system is inspected, tested, and maintained in accordance with PS-09 Blowdown and flare system (NV-00-RG-10053.09). Equipment includes: + Blowdown Valves + Flare Tip Integrity + Nitrogen Flare Purge Valves A function tested blowdown and flare system seeks to prevent escalation of loss of containment through the depressurisation of process inventories. PS-09 aims to assure a functional blowdown system are available at all times that the associated plant is operational so escalation of spill events can be	Negligible personnel costs associated with inspections and maintenance of system.	**Adopted** – benefits of ensuring inspections are undertaken and compliance is maintained outweigh the costs of personnel time.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		prevented by the depressurisation of process inventories via release to flare when initiated rather than to the marine environment.		
NV-CM-79	Blowdown, pressure safety valves	Emergency shutdown systems and shutdown/ safety valves testing, functionality and maintenance in accordance with PS-10 ESD and Blowdown: Pressure safety valves (NV-00-RG-10053.10). Equipment includes: + Pressure safety valves + Pressure vacuum valves + Liquid PV Breakers PS-10 aims to ensure integrity and function is maintained on topsides pressure containing equipment and pipework to prevent a loss of containment from equipment and piping on topsides by controlled disposal via the flare systems or an alternative safe location rather than discharge to the environment.	Negligible personnel costs associated with testing's and maintenance of system.	**Adopted** – benefits of ensuring tests are undertaken and compliance is maintained outweigh the costs of personnel time.
NV-CM-80	Radio communication prior to entering PSZ	Reduces the collision risk as allows for communication to be established and other vessels / FPSO within the PSZ to be made aware of a vessel entering.	Negligible costs involved in communicating presence.	**Adopted** – Benefits considered to outweigh negligible costs.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
NV-CM-14	Dropped object prevention controls	Reduces the risk of impact to topsides process equipment from dropped objects through procedures and standards for lifting equipment inspection and maintenance and lifting procedures.	No additional costs to Santos other than negligible personnel costs of reviewing information.	**Adopted –** environmental benefits of identifying new sensitivities outweighs the low costs of implementing measure.
NV-CM-18	Navigation lighting and aids	Reduces risk of environmental impact from vessel collisions due to ensuring safety requirements are fulfilled and other marine users are aware of the presence of the FPSO and vessels.	Negligible costs of operating and maintaining navigational equipment.	**Adopted** – Benefits considered to outweigh negligible costs.
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-19	Seafarer Certification	Requires appropriately trained and competent personnel, in accordance with Marine Order 70, to navigate vessels to reduce interaction with other marine users.	Costs associated with personnel time in obtaining qualifications.	**Adopted -** Benefits considered to outweigh costs and is a legislated requirement.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
NV-CM-66	Oil pollution emergency plan (OPEP)	OPEP is a response plan to deal with unplanned hydrocarbon spills quickly and efficiently in order to reduce impacts to the marine environment.	Organisational and administrative costs associated with preparing documents, ongoing management (spill response exercises) and implementation of OPEP.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.
NV-CM-67	Incident Response Plan detailing the requirements for preparedness and response to emergencies and crises to protect people and the environment.	Provides detail to ensure the ESD system is activated quickly and efficiently if it has not automatically activated, to reduce the extent of impacts to the marine environment.	Administrative costs of preparing documents.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-59	Vessel spill response plan (SOPEP/SMPEP)	Implements response plans on board vessels to deal with unplanned hydrocarbon releases and spills quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents. Generally undertaken by vessel contractor so time for Santos personal to confirm and check SOPEP/SMPEP in place.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-04	FPSO Planned Maintenance System and class certification system	Compliance with this control ensures that offtake equipment (including the offtake floating hose) is maintained through the following routine checks: + Visual inspections + String hydrotest A maintained floating hose will reduce likelihood of loss of integrity events	Costs associated with maintenance of equipment.	**Adopted -** Benefits of maintaining offtake equipment integrity outweigh the costs

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		during crude transfers.		
Additional Control Measures				
N/A	Pipeline the crude oil to the mainland	Construction and installation of a pipeline to mainland would negate the requirement for offtake tanker presence, therefore remove collision risk and offtake release risk and subsequent crude release to the environment.	Significant costs involved in constructing, installing and operating a pipeline. Additional environmental impacts associated with construction and installation of a pipeline as well as crude release risks associated with transporting the crude via the pipeline.	**Rejected** – Costs which grossly outweigh the environmental benefit.
N/A	Contracting a standby vessel 24 / 7 during NV operations to aid third party vessel detection at sea	Standby vessel to monitor the 500 m PSZ and be equipped with an Automatic Identification System (AIS) to aid vessel detection at sea, and radar to aid in the detection of approaching third party vessels. Reduces risk of vessel collision and subsequent unplanned release of hydrocarbons causing potential harm to the marine environment.	High cost associated with contracting standby vessel. Costs of operating navigational equipment. Additional risks from vessel in the 500 m PSZ.	**Rejected** – Cost grossly disproportionate compared to low risk of a vessel collision. Large cost associated with dedicated standby vessel on location deemed grossly disproportionate compared to risk. Additional risks exist from vessel use.
N/A	Limiting offtake frequency	Limiting offtake frequency will reduce likelihood of collisions further as less offtakes will be undertaken.	Don't have storage capacity on FPSO and significant financial cost as production would have to decrease.	**Rejected** – Costs which grossly outweigh the environmental benefit
N/A	Reducing loading rates	Reducing load rates has the potential to reduce the volume discharge should	Significant financial cost, as offtakes will take longer. Additional risks	**Rejected** – Risk of integrity failure is rare. Costs which grossly outweigh the

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		there be an integrity failure in the offtake equipment	involved with the tanker remaining on location.	environmental benefit and risk. Rates for offtake given in the Berthing and Terminal Handbook and monitored during loading.
N/A	Only accepting tankers that have previous experience successfully loading from NV	Only accepting tanker which have previous experience loading from NV provides additional assurance that the offtakes can be completed successfully.	Significant financial cost, as offtake tanker availability will be constrained. Production may be decreased whilst waiting for suitable offtake tanker.	**Rejected** – Costs which grossly outweigh the environmental benefit and risk.
N/A	Testing and inspection of systems at greater frequency than that detailed by PSAPs	Little environmental benefit. PSAP approach determines function testing and inspection frequency. Frequency may be greater based on a risk based approach (e.g. inspections or analysis results) which indicate further testing and inspection is required. Unwarranted testing is determined to provide little to no integrity assurance benefits.	Costs associated with testing and inspection of systems at greater frequencies.	**Rejected** – Costs which grossly outweigh the environmental benefit. Unwarranted function testing and inspection greater than that of a risk based PSAP risk based approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit
N/A	Response equipment above and beyond SOPEP requirements (e.g. booms) on the FPSO ready to respond to a loss of hydrocarbons	May allow for quicker response to a spill as resources will be within proximity.	Lack of room on the FPSO. Large costs associated with a dedicated resource on location.	**Rejected** – Not feasible due to lack of room on the FPSO and large cost associated with dedicated resources on location deemed grossly disproportionate compared to risk

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
N/A	Radar Beacon (RACON) System	FPSO would appear on the display of the triggering radars, providing range, bearing and identification information. Would alert vessels of FPSO position reducing collision risk	Minimal cost for purchase, and maintenance of radar system.	**Rejected** – due to the number of facilities operating in the area, AMSA wish to restrict the number of RACON systems used

7.8.4 Environmental Impact Assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.6**.

7.8.4.1 Identification of Hotspots for Consequence Analysis

As described in **Section 7.5.6**, all HEVs within the EMBA (low exposure value) are listed in **Table 7-28** below. The values and sensitivities associated with these HEVs have been described in **Appendix D1.** Further to this, **Table 7-28** filters the HEV to identify the hotspots where they meet the criteria described in **Section 7.5.6**.

Table 7-28: Identified High Environmental Value and Hotspot Receptors

Receptor	HEV Value	Exposure Value			Hotspot*
		Low	Moderate	High	
Ningaloo Coast North	3	✓	✓	✓	✓
Outer Ningaloo Coast North	3	✓	✓	✓	
Muiron Islands	2	✓	✓	✓	✓
Ningaloo Coast North	1	✓	✓	✓	
Eighty Mile Beach	5	✓			
Montebello Islands	3	✓	✓		
Lowendal Islands	3	✓			
Barrow Island	3	✓	✓		
Barrow-Montebello Surrounds	3	✓			
Ningaloo Coast South	3	✓	✓	✓	✓
Outer NW Ningaloo	3	✓	✓	✓	✓
Montebello AMP	4	✓	✓		
Shark Bay AMP;	4	✓	✓		
Offshore Ningaloo	4	✓	✓	✓	
Offshore Abrolhos NW	4	✓	✓		
Rankin Bank	5	✓			
Middle Islands Coast	5	✓			

Thevenard Island	5	✓			
Southern Islands Coast	5	✓	✓		
Nearshore Abrolhos	4	✓			
Abrolhos West	2	✓			
Abrolhos Islands Wallabi Group	2	✓			
Outer Abrolhos Islands - Shoals	3	✓			
Outer Shark Bay Coast	3	✓	✓		
Zuytdorp Cliffs - Kalbarri	3	✓	✓		
Carnarvon - Inner Shark Bay	2	✓			

* greater than 5% probability of contact

This process identified the following hotspots:

+ Muiron Islands;
+ Ningaloo Coast North;
+ Ningaloo Coast South; and
+ Outer NW Ningaloo.

Table 7-20 provides a simplified summary of the consequence assessment results for each of the Hotspot areas. The consequence assessment was based on predicted contact and concentration of surface oil, accumulated oil, entrained hydrocarbon and dissolved hydrocarbons. For each Hotspot area the consequence to the key values were assessed using the methodology described in **Section 7.5.6**

The following individual scenarios (as defined in **Section 7.8.1**) leading to a surface release of hydrocarbons have been risk assessed in the below sections:

+ Surface release of Van Gogh crude blend from tank rupture on the FPSO or offtake tanker;
+ Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment;
+ Surface release of Van Gogh crude blend from a rupture or leak in the topside process equipment; and
+ Surface release of Van Gogh crude blend from process upset.

7.8.4.2 Surface release of Van Gogh crude blend from tank rupture on the FPSO or offtake tanker

<table>
<tr><td>Receptors</td><td>Threatened, migratory, and local fauna;
Protected areas;
Physical environment and habitats;
Socio-economic receptors.</td></tr>
<tr><td>Consequence</td><td>IV - Major</td></tr>
<tr><td colspan="2">Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in Table 7-15 and potential impacts to receptors from the moderate exposure values are described in Table 7-16.
<u>Threatened, Migratory, and Local Fauna</u>
With high winds (10 m/s), significantly higher rates of dispersion are predicted, with approximately 65% of the released oil dispersed into the water column after 24 hours (GHD, 2019) A net result of weathering the Van Gogh crude blend oil is effectively losing the remaining volatile fraction of the oil and leaving a further</td></tr>
</table>

degraded, waxier and heavier crude oil in any spill incident (Intertek, 2018), which may persist for some time. The potential sensitive receptors in the surrounding areas of the release will include fish, marine mammals, marine reptiles and seabirds at the sea surface, as discussed **Section 3.2.3** which may come into contact with Van Gogh crude oil leading to skin or eye irritation or oiling of the birds feathers (as described in **Table 7-16**). It is expected that a surface Van Gogh crude blend has the potential to result in an insignificant disruption to the breeding cycle for marine mammals.

The humpback whale (migration and resting) and pygmy blue (distribution, migration and foraging), BIAs overlap the moderate exposure value area. An unplanned release of Van Gogh crude is not expected to interfere with their migration activity. There is the potential for behavioural disruption to the local population as individuals traverse the release.

Deteriorating water quality / chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (**Table 3-8**). Habitat modification, degradation and disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Given the location of the release, and volume of potential hydrocarbon release there is the potential for modification to or a decrease in the availability of quality habitat (shorelines/subsurface), particularly given the volumes of accumulated hydrocarbons (maximum volume of hydrocarbon accumulation is at Ningaloo Coast North – 1,254 tonnes) and persistence of crude. Shoreline accumulation may present a major disruption to shoreline individuals (as described in **Table 7-16**). Volumes of accumulated hydrocarbon may result in a major reduction in area available for seabirds and/or turtles species. The quality of habitat (shorelines/subsurface) may be reduced for a period, with recovery over decades.

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves states that DPaW should 'ensure that important seabird and shorebird breeding and feeding areas are not significantly affected by human activities'. The potential impacts of a hydrocarbon release on seabird breeding and feeding areas are discussed in **Table 7-16**. Impacts in relation to human activities from responding to a spill are described in **Section 6.8**.

<u>Physical Environment and Habitats</u>

In the event of Van Gogh crude blend release, hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a long-term decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. The quality of habitat may be reduced for a significant period with recovery over decades.

As described above, accumulated hydrocarbons on shorelines could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill. Beaches on the Ningaloo Coast are important for green turtles, and to a lesser extent hawksbills turtles, while Muiron Islands has a regionally important nesting site for loggerhead turtles. Impacts to turtles could occur from surface hydrocarbons if oil accumulates on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. The quality of habitat available to the turtles will be reduced, with recovery over a decade.

<u>Protected Areas</u>

The moderate exposure value area intersects several protected areas and AMPs and marine management areas (impacts discussed in **Table 7-16** and AMP details presented in **Section 3.2**). Combined, these areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described in **Table 7-16** and impact on the values of these reserves could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves. Many of these receptors are values of protected areas and there could be a major long term impact on them.

<u>Socio-economic Receptors</u>

There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. A major spill would result in the establishment of a safety exclusion zone around the affected area. A temporary prohibition on fishing activities for a period of time may be in place, and subsequently there is a potential for economic impacts to those affected. Hydrocarbon may also foul fishing equipment which will require cleaning or replacement.

Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Fish have a high capacity to metabolise these hydrocarbons, while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). 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 (Yender et al. 2002). Heritage values are not predicted to be impacted by surface oil although in the short-term there would be an impact on the aesthetic value of the area. There are oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A Van Gogh crude blend subsea release from a well leak has the potential to disrupt these activities if contacted at moderate or high surface exposure values. with associated economic impact, albeit on a temporary basis. Tourism could be affected by spilled Van Gogh crude blend, either from reduced water quality/shoreline oiling preventing recreational activities or reducing aesthetic appeal or from impacts to habitats and marine fauna. marine nature-based tourist activities, resulting in a loss of revenue for operators. Indigenous users may be impacted if a land-based response is required. However, consultation will help manage activities such that potential impacts are reduced to acceptable levels. Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon release were to occur as fish may be 'tainted' as described above. On the basis of the above assessments, a Van Gogh crude blend surface release from a ruptured FPSO fuel tank has the potential to impact an array of receptors, in the longer term. Given the extent, the worst-case consequence is considered to be *Major (IV).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case surface release of Van Gogh crude blend from the FPSO or offtake tanker has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. External impacts to the FPSO or offtake tanker have not occurred within Santos and controls are in place which limit third party vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). The operational area is also a significant distance from major shipping routes and significant fishing effort and associated vessels have not been reported within the operational area since NV production began. Santos have applied controls such as radio communication prior to entering the 500 m PSZ, adherence for offtake tankers to the Berthing and Terminal Handbook (TV-22-IG-00067) and standard navigational controls to ensure likelihood of vessel collision is *Rare*. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case surface release of Van Gogh crude blend from a crude tank rupture on the FPSO or offtake tanker resulting in a *Major (IV)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is Low

7.8.4.3 Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment.

Receptors	Threatened, migratory, and local fauna Physical environment and habitats Protected areas Socio-economic receptors
Consequence	III - Moderate
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values are described in **Table 7-16.** The size of release caused by a rupture or leak in the offtake equipment is significantly smaller than the credible worst-case surface hydrocarbon loss (surface release of Van Gogh crude blend from the FPSO or offtake tanker due to external impact), which has been modelled (**Section 7.8.2.2**) and risk assessed	

(**Section 7.8.4.2**). Given the size of the release (1,286 m^3) a surface release of Van Gogh crude blend caused by a rupture or leak in the offtake equipment will impact a number of receptors as discussed in **Section 7.8.4.2,** however to a lesser degree. The consequence is summarised below: + Although humpback and blue whales may be exposed and a BIA for humpback migration occurs over the operational area, an unplanned release of Van Gogh crude is not expected to interfere with their migration activity. + Accumulated hydrocarbons on shorelines is likely given the volumes of accumulated hydrocarbons on shorelines in the modelling results for the larger Van Gogh crude surface release (**Section 7.8.4.2).** Hydrocarbons could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill, particularly at Ningaloo Coast and Muiron Islands. + The quality of habitat available to the turtles will be reduced should hydrocarbon accumulation on shorelines occur. However, it is expected to a lesser degree than that discussed in **Section 7.8.4.2** due to the smaller volume from a rupture or leak in the offtake equipment. Recovery to shorelines would be expected over medium term (2-10 years). + Hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a long-term decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. However, it is expected to a lesser degree than that discussed in **Section 7.8.4.2** due to the smaller volume from a rupture or leak in the offtake equipment. Recovery to shorelines would be expected over medium term (2-10 years). + There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. Restriction in fishing area may occur and there is a potential for tainting of fish. A Van Gogh crude blend surface release caused by a rupture or leak in the offtake equipment has the potential to impact a number of receptors. Given the extent, the worst-case consequence is considered to be *Moderate (III)*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. External impacts to the offtake equipment have not occurred within Santos and controls are in place which limit third party vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). The Santos Offtake Operations and Pilotage Procedure (NV-91-IG-10010.03) and Berthing and Terminal Handbook (TV-22-IG-00067) provide controls to ensure that a rupture of the offtake equipment does not occur. Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the offtake equipment is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case surface release of Van Gogh crude blend from the offtake equipment resulting in a *Moderate (III)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Very Low**

7.8.4.4 Surface release of Van Gogh crude blend from a rupture or leak in the topside process equipment.

Receptors	Threatened, migratory, and local fauna Physical environment and habitats Socio-economic receptors
Consequence	III- Moderate
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values are described in **Table 7-16.**	

The size of a release of Van Gogh crude blend from topside process equipment is significantly smaller than the credible worst-case surface hydrocarbon loss (surface release of Van Gogh crude blend from the FPSO due to collision event with a vessel or the offtake tanker which ruptures the FPSO crude tank), which has been modelled (**Section 7.8.2.2**) and risk assessed (**Section 7.8.4.2**). Given the size of the release (700 m^3) a surface release of Van Gogh crude blend from topside process equipment will impact receptors to a similar level of consequence as a 'Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment' (**Section 7.8.4.3**), described above. The worst-case consequence is considered to be *Moderate (III).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case surface release of Van Gogh crude blend from a rupture or leak in the topside process equipment has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. External impacts leading to a rupture or leak in the topside process equipment have not occurred within Santos. Controls and processes are in place to prevent escalation of loss of containment by the depressurisation of process inventories. Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the topside process equipment is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case surface release of Van Gogh crude blend from the offtake equipment resulting in a *Moderate (III)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Very Low**

7.8.4.5 Surface release of Van Gogh crude blend from process upset on FPSO

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors from the moderate exposure values are described in **Table 7-16.** The size of a release of Van Gogh crude blend from process upset on FPSO is significantly smaller than the credible worst-case surface hydrocarbon loss (surface release of Van Gogh crude blend from the FPSO due to collision event with a vessel or the offtake tanker which ruptures the FPSO crude tank), which has been modelled (**Section 7.8.2.2**) and risk assessed (**Section 7.8.4.2**). Given the size of the release (35 m^3) a surface release of Van Gogh crude blend from process upset on FPSO will impact receptors to a similar level of consequence as a 'Surface release of Van Gogh crude blend from a rupture or leak in the offtake equipment' (**Section 7.8.4.3**), described above. The worst-case consequence is considered to be *Minor (II)* Detectable but insignificant change to local population, industry or ecosystem factors). A release may impact local marine fauna in the immediate site of release and relate to short term behavioural change. Impacts to water quality will be localised but detectable and occur for a short duration whilst the release disperses. Rapid recovery is expected.	
Likelihood	C - Occasional
The likelihood of a release of up to 35m^3 over the side of the FPSO into the ocean is considered *Occasional* with controls in place, as it has occurred before in Santos OR could occur within months to years.	
Residual Risk	The residual risk associated with this event is **Low**

7.8.5 Demonstration of ALARP

External impact controls

Vessel activities are required to maintain the functioning of the FPSO and cannot be eliminated. The FPSO is marked on Australian Hydrographic Service Nautical Charts which identifies the location of the FPSO and offtake tanker berthing activities to other sea users. Collision prevention equipment (i.e. navigation and radio equipment) and seagoing qualifications used on vessels/FPSO/offtake tankers will comply with applicable AMSA Marine Orders / MARPOL requirements. The FPSO and offtake tankers have double sides protecting crude oil tanks which reduce the potential for a vessel collision to rupture these tanks.

Offtake tankers are subject to acceptance criteria stated in Berthing and Terminal Handbook (TV-22-IG-00067), which is used to assess the suitability of the proposed offtake tanker to comply with the equipment and operational procedures developed to ensure safe offtake. The criteria is acknowledged and accepted by the Offtake Tanker Master. The procedures outlined in the Berthing and Terminal Handbook (TV-22-IG-00067) provide instructions and requirements to reduce the environmental and safety risks during offtake tanker berthing, departure and Van Gogh crude blend cargo loading. Instructions and requirements include:

+ Defined safe weather berthing limits (limitations to swell height and wind speed)
+ Offtake tanker specifications (including requirement for Navigation lights and communications)
+ Specifications for offtake cargo loading equipment.
+ Qualifications of the offtake crew
+ Tanker berthing hours (restricting to daylight)
+ Communication requirements between the offtake tanker and NV FPSO.
+ Preparations for arrival and pilotage - Berthing and offloading activities supervised by a specialised Pilot and Mooring Master
+ Berthing requirements
+ Arrival requirements
+ Loading requirements, including maximum loading rates and bow watch requirements
+ Departure requirements
+ Emergency disconnection process.

Table 8-2 details the Performance Standards relating to the NV-CM-75 Berthing and Terminal Handbook (TV-22-IG-00067). Opportunity to add controls to the already extensive requirements within the Berthing and Terminal Handbook (TV-22-IG-00067) to reduce risks during offtake includes:

+ Further restricting safe weather berthing limits
+ Reducing loading rates
+ Only accepting tankers that have previous experience successfully loading from NV

As assessed in **Table 7-27**, these have controls present costs which grossly outweigh environmental benefit.

The Berthing and Terminal Handbook (TV-22-IG-00067) includes the requirement that a specialist Pilot, qualified to Santos requirements, undertakes the pilotage of the offtake tanker for berthing and un-berthing operation. The use of a specialist Pilot, rather than the offtake tanker Vessel Master provides greater assurance that the berthing is conducted in a safe manner in keeping with good seamanship practices and Santos requirements. This is pilotage is compulsory and determined to be ALARP.

The Berthing and Terminal Handbook (TV-22-IG-00067) includes the requirement an initial safety / environmental inspection is conducted by the Pilot and or Mooring Master on boarding of the offtake tanker for pilotage. Additional checks / pre berthing inspections may be conducted on the tanker by Santos appointed personnel if the following triggers are present:

+ Constrained tanker availability due to market conditions
+ Older tonnage (Tanker > 20 yrs. age)
+ New buyers of VG crude
+ Previous detentions / adverse reports

Given the Berthing and Terminal Handbook (TV-22-IG-00067) provides the ability to additional check / inspect tankers based on certain triggers, further scheduled inspections are not warranted and unlikely to present new finding. When coupled with the acceptance criteria and offtake tanker vetting, the inspection process detailed in the Berthing and Terminal Handbook (TV-22-IG-00067) is considered ALARP.

Additional controls such as removing the requirement for offtake tankers through installation of a pipeline to mainland and limiting offtakes through reducing production present significant costs and grossly outweigh the environmental benefits, as described in **Table 7-27**. The acceptance of third-party offtake tankers is regulated by Santos through the use of the criteria detailed within the Berthing and Terminal Handbook (TV-22-IG-00067), as described above, and provides assurance that the offtake tanker meets specified criteria and will comply with the Berthing and Terminal Handbook (TV-22-IG-00067).

Support, project vessel and offtake tanker movement within the operational area is coordinated from the FPSO with permission needed for entry into the 500 m PSZ; this reduces the potential for vessel collisions if SIMOPS are occurring.

Contracting a standby vessel 24/7 to monitor the 500 m PSZ was investigated as it has potential to reduce risk of errant vessels entering the PSZ and colliding with the FPSO or offtake tanker. However significant cost (approximately $200k per day) is associated with having a dedicated standby vessel on location, which is disproportionate compared to the environmental benefit and low risk of a vessel collision. In addition the standby vessel poses additional environmental and safety risks (e.g. collision risks).

There are no further controls that are considered to provide a net benefit in reducing the likelihood or consequence of a vessel collision and subsequent release of crude to the marine environment and thus the controls are considered to reduce the risk of Van Gough crude blend from entering the marine environment to ALARP.

Crude oil offtake controls

Offloading of crude oil from the FPSO to an offtake tanker is performed under the procedures and requirements outlined within the Berthing and Terminal Handbook (TV-22-IG-00067) and Offtake Operations and Pilotage Procedure (NV-91-IG-10010.03). As described above, offtake tanker suitability in terms of design, equipment and crew competency, is determined through acceptance criteria detailed in Berthing and Terminal Handbook (TV-22-IG-00067) and includes a pre-arrival vetting questionnaire and OCIMF ship inspection report (SIRE) by a third party vetting agency and from pre cargo loading checks undertaken by a Loading Master when the tanker is stationed at the facility.

As detailed above, additional controls were assessed which would negate or reduce the requirement for offtake tanker visits to the FPSO but were determined to present significant costs and grossly outweigh the environmental benefit.

The offtake equipment on board the FPSO must meet industry standards and Class requirements. The functionality of the offtake equipment on the FPSO is assured through regular inspection, testing and maintenance.

There are no further controls that are considered to provide a net benefit in reducing the likelihood or consequence and thus the controls are considered to reduce the risk of Van Gough crude blend from entering the marine environment to ALARP.

Topside process system controls

Crude oil processing equipment (e.g. vessels, valves, piping and pumps) are inspected, tested and maintained as per the Performance Standard Assurance Plans (PSAPs) and the CMMS which manage the correct functioning of equipment and systems that are critical in ensuring hydrocarbon containment. FPSO topsides hydrocarbon containing equipment meets inspection criteria as specified in PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08) which provides frequency and inspection philosophies for:

+ Topsides & offloading pressure containing equipment
+ Pumps
+ Engine Room and Cargo Equipment

A number of safety systems are utilised on the hydrocarbon processing equipment which reduce the likelihood of loss of integrity and/or release of crude oil. These include pressure safety valves (PSVs), emergency blowdown systems and emergency shutdown (ESD) systems

The primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005). This system responds to both automatic and manual activation, with automatic activation triggered by abnormal process conditions, such as pressure drop across the subsea production system. The emergency shutdown system functionality and reliability is maintained through regular testing of the shutdown systems and the subsea valves. The regular testing and maintenance of the emergency shutdown and blowdown systems are managed through (PSAPs), which provide the work instructions and performance criteria to test and service the shutdown and blowdown systems. The relevant PSAPs contain specific performance criteria as detailed below:

- PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06). The performance criteria specified in PS-06 includes:
  - Appropriate ESDV location, ESDV actuation requirements, ESD close on demand timings, process safety time calculations, reliability levels, acceptable leakage rates for riser ESDVs, and ESDV positions.
- PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). The performance criteria for Safety instrumented Systems in PS-08 includes:
  - The Safety Integrated system shall initiate shutdown and blowdown of the process during abnormal process conditions in accordance with the Cause and Effects Diagrams and alarm and trip schedule, ESD pushbutton locations, Reliability/availability achievements through redundancy, backup power, regular function testing and self-diagnostic capability.
- PS-10 ESD and Blowdown: Pressure Safety Valves (NV-00-RG-10053.10). The performance criteria specified in PS-10 includes:
  - PSV design and operational requirements, PSV relieve at set pressure, provision of overpressure and vacuum relief to cargo tanks,
  - PS-10 ensures integrity and function is maintained on topsides pressure containing equipment and pipework to prevent a loss of containment from equipment and piping on topsides by controlled disposal via the flare systems or an alternative safe location rather than discharge to the marine environment.

A functioning and tested ESD and blowdown system in accordance with the relevant PSAPs is designed retain liquid in on board and blowdown gas rather than discharge to environment in the event of an emergency situation. Other means of mitigating an emergency situation (such as over pressure) may be to discharge or release hydrocarbon to the marine environment. The NV ESD and blowdown system is therefore considered ALARP.

The relevant PSAPs are listed as control measures with relevant performance standards in **Table 8-2**.

Function testing and inspection frequency and intervals within Santos PSAPs are based on a combination of:

- Industry recommendations / standards
- Manufacturers recommendations
- Statutory obligations
- Integrity risk (based on previous inspections or other triggers)

Unwarranted function testing and inspection greater than that of a PSAP approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit.

A PSAP deviation process is detailed in the Santos Permitted Operations Procedure (QE-00-IG-00183), which provides allowance for deferral of PSAP assurance activities on a completion of a risk assessment process, which shows safe operations can continue and integrity can be maintained. Further details on this process is provided in **Section 8.3.1.1**.

Placement of response equipment (e.g. booms) on location (the FPSO or support vessels), ready to respond to a loss of hydrocarbons event was investigated however the cost of upkeep and the space required for the equipment was determined to be grossly disproportionate to the benefits.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos have where practicable, adopted all reasonable controls for reducing the risk.

With the above control measures in place, Santos deem that the activity risk from an unplanned surface release of Van Gogh crude blend is ALARP.

7.8.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes –Residual risk is ranked as Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with OPGGS Regulations. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities including the Montebello Australian Marine Park, the Barrow Island Marine Park Management Area, Montebello Marine Park, Muiron Island Marine Management Area, Ningaloo Australian Marine Park.; and Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015) + Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia 2017-2027 (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016) + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016)

	+ Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

The likelihood of a Van Gogh crude blend surface release is extremely low (remote) when considering industry statistics, Santos statistics and the preventative controls in place. Additional industry standard control measures to reduce the chance of the event occurring (and minimise impacts) have also been implemented including (but not limited to) such as the navigational aids, Terminal Handbook, Santos Performance Standards (PS), crew training and awareness and a spill response plans (the SOPEP and OPEP).

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect of the NV Operations.

In accordance with Santos risk assessment process, the residual risk is Low and ALARP. The proposed control measures will reduce the risk of impacts from a Van Gogh crude blend surface release to a level that is considered acceptable.

7.9 Surface Release of Marine Diesel Oil to the Marine Environment

7.9.1 Description of Event

Event

The following scenarios could result in a MDO release to the surface:

No.	Scenario	Maximum credible volume
1	Surface release of MDO from an FPSO or vessel as a result of an external impact (vessel collision) which ruptures an MDO tank	1,519 m^3 over 1 hour
2	Release of MDO due to leaking or ruptured bunker transfer equipment	15 m^3 over 15 minutes

1. Surface release of MDO from an FPSO or vessel as a result of an external impact (vessel collision) which ruptures an MDO tank

Collisions between a vessel and the FPSO could occur during supply or IMR activities or offtake tanker berthing activities. A combined inventory of 3,763 m^3 exists in FPSO MDO bunker tanks, with the largest bunker tank having a capacity of 1,519 m^3. Engine room diesel storage is 56 m^3 with 4 m^3 stored in the emergency generator room. The maximum credible release from this event is therefore 1,519 m^3 over 1 hour.

Collisions between supply or project vessel and a third party vessels could occur during NV operations. The single tank inventory for vessels utilised is typically 329 m^3 based on the current contracted vessels. The maximum credible release from this event is 329 m^3 over 1 hour.

	Note, it is not credible that the total storage volume of the vessel would be lost, as fuel is stored in more than one tank. 2. Release of MDO due to leaking or ruptured bunker transfer equipment The potential exists for MDO to be spilled directly or indirectly (via deck drainage) to the marine environment. A total rupture or failure of a bunker transfer equipment such as the hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps, for a period of up to fifteen minutes, may result in approximately 15 m^3 MDO to reaching the marine environment. The maximum credible release of MDO to the marine environment is therefore 1,519 m^3, based on the largest bunker tank of the FPSO (Scenario 1).
Extent	Stochastic modelling determined that the hydrocarbon extent based on moderate exposure values (**Section 7.5.5**) is: + Surface oil may occur out to 220 km from the release location. + Dissolved hydrocarbons may occur 240 km from the release location. + Entrained hydrocarbon may occur out to 240 km from the release location. + Shoreline accumulation may occur at two HEVs, the furthest being Ningaloo Coast North, approximately 40 km from the release location.
Duration	One hour. Loss is instantaneous through the rupture.

7.9.2 Nature and Scale of Impacts

Hydrocarbon spills will cause a decline in water quality and may cause chemical (e.g. toxic) and physical impacts to marine species (e.g. coating of emergent habitats, oiling of wildlife at sea surface). The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (i.e. extent, duration) and sensitivity of the receptor.

<u>Potential receptors: Shallow benthic, intertidal and shoreline habitats; plankton; invertebrates; fish; marine mammals; marine reptiles; birds (seabirds and shorebirds); fisheries; oil and gas industry; tourism; KEFs; and State and Commonwealth marine reserves and Australian Marine Parks.</u>

As a light hydrocarbon, MDO undergoes rapid spreading and evaporative loss in warm waters, indicating that a surface slick will be temporary, with approximately 40% of the released volume evaporating within 40 hours. The high rate of evaporation means that little MDO will become entrained and few aromatic hydrocarbons are predicted to become dissolved.

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are further described in **Table 7-16.**

7.9.2.1 Hydrocarbon Weathering Behaviour

ITOPF (2011) and the AMOSC (2011) categorise MDO as a light 'group II' hydrocarbon. In the marine environment, MDO is expected to behave as follows:

+ MDO will spread rapidly in the direction of the prevailing wind and waves;
+ Evaporation will be the dominant process contributing to the fate of spilled diesel from the sea surface and will account for 60 to 80% reduction of the net hydrocarbon balance;
+ The evaporation rate of diesel will increase in warmer air and sea temperatures; and
+ MDO residues usually consist of heavy compounds that may persist longer and will tend to disperse as oil droplets into the upper layers of the water column.

Under low winds (1 m/s), 60% of the surface slick is predicted to remain after 120 hours (5 days). Under moderate winds (5 m/s), 40% of the initial surface slick is predicted to remain after 24 hours decreasing further to ~10% after 48 hours and 1% after 72 hours. With high winds (10 m/s), the surface slick is predicted to be almost entirely evaporated and dispersed after 12 hours (GHD, 2019) (**Figure 7-6**).

Marine Diesel (IKU) has a very low tendency for emulsion formation, with only 1% water content entrained into the surface slick after 120 hours for all wind conditions assessed (GHD, 2019) (**Figure 7-6**).

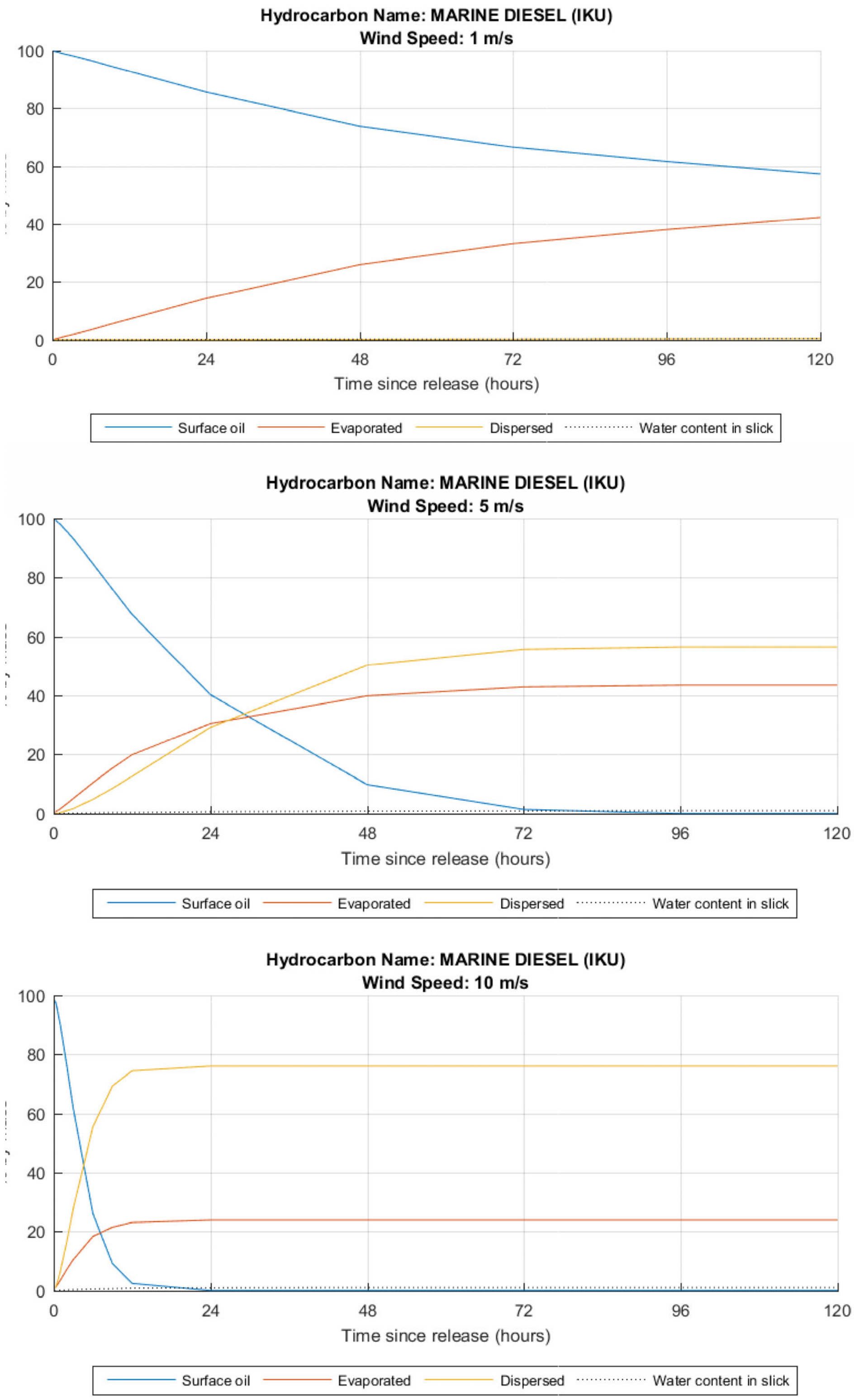

Figure 7-6: Simulated weathering of the SINTEF Marine Diesel (IKU) hydrocarbon for constant wind speeds of 1 m/s (top), 5 m/s (middle) and 10 m/s (bottom) (GHD, 2019)

7.9.2.2 Spill Modelling Results

To determine the spatial extent of impacts from a potential surface release of MDO, and the dispersion characteristics over time, modelling was completed by GHD (GHD, 2019). A volume of 1,519 m^3 released over 1 hour was modelled at the FPSO surface location. MDO weathering behaviour modelling was undertaken by APASA (APASA, 2013b).

Modelling results have been provided for each of the four hydrocarbon fates: shoreline accumulation; surface; dissolved and entrained.

The modelling results are presented for the fate of hydrocarbon at the exposure values defined in **Section 7.5.5** has been provided for the purposes of risk evaluation, displaying the following parameters:

+ Minimum time to contact from moderate and high exposure value;
+ Maximum hydrocarbon concentration from high exposure value;
+ Maximum oil accumulation on shoreline from moderate and high exposure value; and
+ Length of shoreline oiled.

Further parameters required to inform spill response strategies are described further in the NV Operations OPEP (TV-00-RI-00003.02).

<u>Surface Oil</u>

Low

Stochastic modelling determined that surface oil at concentrations equal to or greater than 1 g/m^2 could extend up to 280 km from the release location. HEVs with the potential to be contacted at the low exposure value are:

+ Muiron Islands;
+ Ningaloo Coast North;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Moderate and High

Stochastic modelling determined that surface oil at moderate exposure value of 10 g/m^2 may occur out to 220 km from the release location. HEVs with the potential to be contacted at the moderate exposure value are:

+ Ningaloo Coast North;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Surface oil at the high exposure value of 50 g/m^2 may occur out to 200 km from the release location.

<u>Dissolved Hydrocarbons</u>

Low

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 10 ppb may occur 260 km from the release location.

Moderate

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 50 ppb may occur 240 km from the release location. Dissolved hydrocarbons at concentrations of 50 ppb may contact five HEVs (Muiron

Islands, Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo), with the furthest being Muiron Islands which is approximately 50 km from the release location.

High

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 400 ppb could travel up to 100 km from the release location. At this concentration contact may occur at the Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo.

Entrained hydrocarbon

Low

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 10 ppb may occur out to 300 km from the release location.

Moderate and High

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 100 ppb may occur out to 240 km from the release location. At the moderate exposure value of 100 ppb there is greater than 1% probability of entrained hydrocarbon reaching four HEVs: Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo. All these HEVs may be contacted at the high exposure value of 500 ppb.

Shoreline Accumulation

Low

Shoreline accumulation above the low exposure value of 10 g/m^2 may occur at four HEVs with the furthest from the release location being Outer Shark Bay Coast, approximately 600 km from the release location.

Moderate and High

Shoreline accumulation above the moderate exposure value of 100 g/m^2 may occur at two HEVs:

+ Muiron Islands; and
+ Ningaloo Coast North.

The furthest being Ningaloo Coast North, approximately 40 km from the release location.

Shoreline accumulation above the high exposure value of 1,000 g/m^2 may also occur at both of these islands.

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Table 7-29: Summary of Hydrocarbon Contact with Receptors: 1,519 m³ Surface MDO Release

Receptor	Receptor Type	Minimum time to contact (days)							Maximum hydrocarbon concentration							Maximum oil ashore (tonnes)	Maximum length of oiled shoreline (km)
		Moderate exposure values				High exposure values			Moderate exposure values				High exposure values				
		Shoreline accumulation 100 g/m^2	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (25 g/m^2)	Shoreline accumulation (100 gm^2)	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (25 g/m^2)	Shoreline accumulation (100 g/m^2)	Shoreline accumulation (100 g/m^2)
Muiron Islands	Emergent	2	2	2	2.3	NC	2	NC	2,047	24	113	234	NC	1,904	NC	19	11
Ningaloo Coast North	Emergent	2	1	1	1.3	2	2	1	18,555	79	645	1,197	978	18,555	80	176	20
Outer Ningaloo Coast North	Intertidal	NC	<1	1	<1	2	NC	1	NC	260	691	1,224	887	NC	258	NC	NC
Outer NW Ningaloo	Submerged	NC	<1	<1	<1	1	NC	<1	NC	318	577	1,280	909	NC	317	NC	NC
Offshore Ningaloo	Submerged	NC	<1	<1	<1	<1	NC	<1	NC	614	471	1,223	649	NC	615	NC	NC

NC = no contact

NA = not applicable

7.9.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-10]

The control measures considered for this event are shown below (**Table 7-30**) EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-30: Control Measures Evaluation for a Surface Release of MDO

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
NV-CM-76	Hull integrity	FPSO hull is double-sided design providing two physical barriers between MDO tanks and the marine environment for side impact, reducing potential for release in the event of collision.	FPSO hull is double-sided design and control is already in place. Costs involved with maintaining hull integrity.	**Adopted** - The benefits to safety and the environment, (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-77	Berthing and Terminal Handbook (TV-22-IG-00067)	The Berthing and Terminal Handbook (TV-22-IG-00067) provides details for safe approach (e.g. daylight hours, speed, pilot accreditation) and berthing of the offtake tanker to the FPSO, reducing potential for release in the event of collision. The Berthing and Terminal Handbook also defines parameters (e.g. metocean) for offtake to occur and reducing risk of release events. Offtake tankers are subject to acceptance criteria stated in the Berthing and Terminal Handbook, which is	Personnel costs associated with ensuring procedures are in place, up to date and implemented.	**Adopted** – benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		used to assess the suitability of the proposed offtake tanker to comply with the equipment and operational procedures developed to ensure safe offtake. This process also vets offtake tankers against the Oil Companies International Marine Forum (OCIMF) guidelines. Vetting offtake tankers against these guidelines ensures best practice is followed during offtake and approach and reduces the likelihood of a release occurring.		
NV-CM-81	NV Bunkering Operation Procedure (NV-91-IG-10006.03)	The NV Bunkering Operation Procedure (NV-91-IG-10006.03) provides details on the fuel bunkering process to be undertaken. Following the procedure reduces the potential for release in during bunkering. Requires the use of dry break coupling (bunkering hose) and break-away coupling limit the MDO losses in an emergency.	Personnel costs associated with ensuring procedures are in place, up to date and implemented.	**Adopted** – benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.
NV-CM-19	Seafarer Certification	Requires appropriately trained and competent personnel, in accordance with Marine Order 70, to navigate vessels to	Costs associated with personnel time in obtaining qualifications.	**Adopted -** Benefits considered to outweigh costs and is a legislated requirement.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		reduce interaction with other marine users.		
NV-CM-18	Navigation lighting and aids	Reduces risk of environmental impact from vessel collisions due to ensuring safety requirements are fulfilled and other marine users are aware of the presence FPSO and vessels.	Negligible costs of operating and maintaining navigational equipment.	**Adopted** – Benefits considered to outweigh negligible costs.
NV-CM-80	Radio communicatio n prior to entering PSZ	Reduces the collision risk as allows for communication to be established and other vessels / FPSO within the PSZ to be made aware of a vessel entering.	Negligible costs involved in communicating presence.	**Adopted** – Benefits considered to outweigh negligible costs.
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-66	Oil pollution emergency plan (OPEP)	Implements response plan to deal with an unplanned hydrocarbon spills quickly and efficiently in order to reduce impacts to the marine environment.	Personnel and administrative costs associated with preparing documents, ongoing management (spill response exercises) and implementation of OPEP.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
NV-CM-67	Incident Response Plan detailing the requirements for preparedness and response to emergencies and crises to protect people and the environment.	Provides detail to ensure the ESD system is activated quickly and efficiently if it has not automatically activated, to reduce the extent of impacts to the marine environment.	Administrative costs of preparing documents.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-59	Vessel spill response plan (SOPEP/SMPEP)	Implements response plans on board vessels to deal with unplanned hydrocarbon releases and spills quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents. Generally undertaken by vessel contractor so time for Santos personal to confirm and check SOPEP/SMPEP in place.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-58	Spill Response Equipment	Provides a means to prevent any deck spills of MDO on vessels and FPSO reaching the sea.	Costs associated with stocking spill response equipment on vessels and FPSO.	**Adopted** – Benefits of stocking, using and maintaining spill response equipment outweighs the costs of personnel time.
Additional control measures				
N/A	Contracting a standby vessel 24 / 7 during NV operations	Standby vessel to monitor the 500 m PSZ and be equipped with an Automatic Identification System (AIS) to aid vessel detection at sea, and radar to aid in the detection of approaching third party vessels. Reduces risk of vessel collision and subsequent unplanned release of hydrocarbons causing potential	High cost associated with contracting standby vessel. Negligible costs of operating navigational equipment. Additional risks from vessel in the 500 m PSZ	**Rejected** – Cost grossly disproportionate compared to low risk of a vessel collision. Large cost associated with dedicated standby vessel on location deemed grossly disproportionate compared to low risk of large MDO spill. Additional risks exist from vessel use.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		harm to the marine environment.		
N/A	Zero fuel bunkering via hose	Removes spill risk from hose operations.	Cost associated with transfer of MDO via drums or containers or significant modification of the FPSO to allow additional fuel storage. Cost associated with vessel transits and risk transfer to Health and Safety issues with additional trips to port instead. Would significantly increase the schedule to include multiple trips.	**Rejected** – Storage of fuel on FPSO would result in unacceptable transfer of environmental risks to OHS/operational risks and would not eliminate risk of MDO spills to sea. Costs associated with implementing control is deemed grossly disproportionate to environmental benefit and low risk activity with standard controls in place.
N/A	Response equipment above and beyond SOPEP requirements (e.g. booms) on vessels ready to respond to a loss of hydrocarbons	May allow for quicker response to a spill as resources will be within proximity.	Lack of room on vessels. Large costs associated with a dedicated resource on location.	**Rejected** – Not feasible due to lack of room vessels and large cost associated with dedicated resources on location deemed grossly disproportionate compared to risk
N/A	Require all vessels involved in the NV Operations to be double hulled.	Reduces the likelihood of a loss of hydrocarbon inventory in the highly unlikely event of a vessel collision, minimising potential environmental impact.	Vessels are subject to availability and are required to meet Santos standards during activities; requirement of a double hull on vessels would limit the number available to Santos; requiring vessels to be refitted to ensure double hulls would also be of high cost.	**Rejected** – Large costs associated with vessel selection and by having an activity schedule determined by vessel availability deemed grossly disproportionate compared to low risk of a vessel collision and low risk of a large MDO spill.
N/A	Additional storage for MDO reducing	Would limit the need for bunkering	Additional storage for MDO would be	**Rejected** – Increase in MDO storage on the FPSO is not feasible as

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
	need for bunkering	transfers as more MDO can be stored	required on the FPSO	would require significant and costly engineering upgrades

7.9.4 Environmental Impact Assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.6**

7.9.4.1 Identification of Hotspots for Consequence Analysis

As described in **Section 7.5.6**, all HEVs within the EMBA (low exposure value) are listed in **Table 7-31** below. The values and sensitivities associated with these HEVs have been described in **Appendix D1.** Further to this, **Table 7-31** filters the HEV to identify the hotspots where they meet the criteria described in **Section 7.5.6.**

Table 7-31 Identified High Environmental Value and Hotspot Receptors

Receptor	HEV Value	Exposure Value*			Hotspot
		Low	Moderate	High	
Ningaloo Coast North	3	✓	✓	✓	
Outer Ningaloo Coast North	3	✓	✓	✓	
Muiron Islands	2	✓	✓	✓	
Ningaloo Coast North	1	✓	✓	✓	
Ningaloo Coast South	3	✓			
Outer NW Ningaloo	3	✓	✓	✓	✓
Offshore Ningaloo	4	✓	✓	✓	✓
Southern Islands Coast	5	✓			
Outer Shark Bay Coast	3	✓			

* greater than 5% probability of contact

This process identified the following hotspots:

+ Ningaloo Coast North; and
+ Outer NW Ningaloo.

Table 7-20 provides a simplified summary of the consequence assessment results for each of the Hotspot areas. The consequence assessment was based on predicted contact and concentration of surface oil, accumulated oil, entrained hydrocarbon and dissolved hydrocarbons. For each Hotspot area the consequence to the key values were assessed using the methodology described in **Section 7.5.6**.

The following individual scenarios (as defined in **Section 7.7.1**) leading to surface release of MDO have been risk assessed in the below sections:

+ Release of MDO from an FPSO or vessel as a result of an external impact (vessel collision); and
+ Release of MDO due to leaking or ruptured bunker transfer equipment.

7.9.4.2 Release of MDO from the FPSO or vessel as a result of an external impact (vessel collision)

Receptors	Threatened, migratory, and local fauna

	Protected areas Physical environment and habitats Socio-economic receptors
Consequence	III - Moderate

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are described in **Table 7-16**.

Threatened, Migratory, and Local Fauna

A surface release of MDO to the marine environment would result in a localised reduction in water quality in the upper surface waters of the water column. As a light hydrocarbon, MDO undergoes rapid spreading and evaporative loss in warm waters, indicating that a surface slick will be temporary, with approximately 40% of the released volume evaporating within 40 hours. The high rate of evaporation means that little MDO will become entrained and few aromatic hydrocarbons are predicted to become dissolved reducing impact to marine fauna. Surface oil, and entrained hydrocarbon in the sea surface layer, could have the physical effect of coating fauna interacting within and under the surface, including plankton, pelagic invertebrates and fishes, marine reptiles, marine mammals and seabirds, and may also cause slight secondary effects through ingestion after preening for seabirds, or through ingestion of oiled fish (as described in **Table 7-16**).

The humpback whale (migration and resting) and pygmy blue whale (distribution, migration and foraging) BIAs overlap the moderate exposure value area. An unplanned release of MDO is not expected to interfere with their migration activity. There is the potential for behavioural disruption to the local population as individuals traverse the release.

Deteriorating water quality / chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (**Table 3-8**). Habitat modification, degradation and disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Given the location of the release, and volume of potential hydrocarbon release there is the potential for modification to or a decrease in the availability of quality habitat (shorelines/subsurface), particularly given the volumes of accumulated hydrocarbons (maximum volume of hydrocarbon accumulation is at Ningaloo Coast North – 176 tonnes). Shoreline accumulation may present a major disruption to shoreline individuals (as described in **Table 7-16**). Volumes of accumulated hydrocarbon may result in a major reduction in area available for seabirds and/or turtles species. The quality of habitat (shorelines/subsurface) may be reduced for a period, with recovery over the medium term (2 – 10 years).

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves states that DPaW should 'ensure that important seabird and shorebird breeding and feeding areas are not significantly affected by human activities'. The potential impacts of a hydrocarbon release on seabird breeding and feeding areas are discussed in **Table 7-16**. Impacts in relation to human activities from responding to a spill are described in **Section 6.8**.

Physical Environment and Habitats

In the event of MDO release, hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. The quality of habitat may be reduced for a significant period with recovery over the medium term (2 – 10 years).

As described above, accumulated hydrocarbons on shorelines could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill. Beaches on the Ningaloo Coast are important for green turtles, and to a lesser extent hawksbills turtles, while Muiron Islands has a regionally important nesting site for loggerhead turtles. Impacts to turtles could occur from surface hydrocarbons if MDO accumulates on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. The quality of habitat available to the turtles will be reduced, with recovery over the medium term.

Protected Areas

The moderate exposure value area intersects several protected areas and AMPs and marine management areas (impacts discussed in **Table 7-16** and AMP details presented in **Section 3.2**). Combined, these areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described in **Table 7-16** and impact on the values of these reserves could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves. <u>Socio-economic Receptors</u> There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. However, the high rate of evaporation means that little MDO will become entrained and few aromatic hydrocarbons are predicted to become dissolved (approximately 40% of the released volume evaporating within 40 hours). The impacts to fishing activities are expected to be temporary. Heritage values are not predicted to be impacted by surface oil although in the short-term there would be an impact on the aesthetic value of the area. A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A large surface MDO spill has the potential to disrupt these activities, with associated economic impact, albeit on a temporary basis. Minor volumes of MDO lost to the surface are unlikely to pose a disruption. Tourism could be affected by spilled MDO, either from reduced water quality/shoreline oiling preventing recreational activities or reducing aesthetic appeal or from impacts to habitats and marine fauna. Based on the above assessments, a loss of MDO from the FPSO or vessel tank rupture, has the potential to impact an array of receptors. Given the extent, the worst-case consequence is considered to be *Moderate (III).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case surface release of MDO from the FPSO or vessel tanks as a result of external impact (vessel collision) has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term. External impacts to the FPSO or vessels operating within the operational area have not occurred within Santos and controls are in place which limit third party vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). The operational area is also a significant distance (40 km) from major shipping routes and significant fishing effort and associated vessels have not been reported within the operational area since NV production began. Santos have applied controls such as radio communication for vessels prior to entering the 500 m PSZ and adherence to navigational controls to ensure likelihood of vessel collision is *Rare*. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case surface release of MDO from the FPSO or vessel tanks as a result of external impact (vessel collision) resulting in a *Moderate (III)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Very Low**

7.9.4.3 Release of MDO due to leaking or ruptured bunker transfer equipment

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	I - Negligible
Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors found within the EMBA are described in **Table 7-16**. It is considered that there is no potential for contact with sensitive receptor locations above surface (10 g/m^2), entrained (100 ppb) or dissolved (10 ppb) exposure value concentrations from an 8 m^3 spill of marine diesel within the operational area.	

For marine mammals that may be exposed to the more toxic aromatic components of the minor spills, toxic effects are considered unlikely since these species are mobile and therefore will not be constantly exposed for extended durations that would be required to cause any major toxic effects. Although humpback and blue whales may be exposed and a BIA for humpback migration occurs over the operational area, a bunkering release is not expected to interfere with their migration activity. It is possible that individual turtles may be encountered and come into contact with the release, however considering the water depths of the operational area compared to observed water depths of internesting turtles large numbers of the species are not expected. The consequence of an MDO spill are presented in **Table 7-16.** A release of MDO during bunkering will be much reduced in terms of spatial and temporal scales compared to a worst case loss of MDO from the FPSO. A loss of MDO from leaking or ruptured bunker transfer equipment, has the potential to impact local environment only. Given the extent, the worst-case consequence is considered to be Negligible (I).	
Likelihood	Occasional
In accordance with the Santos Risk Matrix, a worst-case surface release of MDO from the due to leaking or ruptured bunker transfer equipment has been defined as a '*Occasional'* as it has occurred before in Santos OR could occur within months to years'. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of an MDO release due to leaking or ruptured bunker transfer equipment resulting in a *Negligible (I)* consequence is considered to be *Occasional.*	
Residual Risk	The residual risk associated with this event is **Low**

7.9.5 Demonstration of ALARP

Vessel collision controls

Vessel activities are required to maintain the functioning of the FPSO and cannot be eliminated. The FPSO is marked on Australian Hydrographic Service Nautical Charts which identifies the location of the FPSO and offtake tanker berthing activities to other sea users. Collision prevention equipment (i.e. navigation and radio equipment) and seagoing qualifications used on vessels/FPSO/offtake tankers will comply with applicable AMSA Marine Orders / MARPOL requirements. The FPSO has double sides protecting MDO tanks which reduce the potential for a vessel collision to rupture these tanks.

Support, project vessel and offtake tanker movement within the operational area is coordinated from the FPSO with permission needed for entry into the 500 m PSZ; this reduces the potential for support vessel collisions if SIMOPS are occurring.

Further to standard collision prevention measures used by all vessels, procedures outlined in the Berthing and Terminal Handbook (TV-22-IG-00067) provide controls to reduce the risk of collision during offtake tanker berthing and crude oil cargo loading. These handbook procedures are communicated and accepted by the Offtake Tanker Master prior to entering the operational area. Berthing activities supervised by a specialised Pilot and Mooring Master.

Additional controls such as removing the requirement for offtake tankers through installation of a pipeline to mainland and limiting offtakes through reducing production present significant costs and grossly outweigh the environmental benefits, as described in **Table 7-30**. The acceptance of third-party offtake tankers is regulated by Santos through the use of the criteria detailed within the Berthing and Terminal Handbook (TV-22-IG-00067), as described above, and provides assurance that the offtake tanker meets specified criteria and will comply with the Berthing and Terminal Handbook (TV-22-IG-00067).

Contracting a standby vessel 24/7 to monitor the 500 m PSZ was investigated as it has potential to reduce risk of errant vessels entering the PSZ and colliding with the FPSO or offtake tanker. However significant cost (approximately $200k per day) is associated with having a dedicated standby vessel on location, which is disproportionate compared to the environmental benefit and low risk of a vessel collision. In addition the standby vessel poses additional environmental and safety risks (e.g. collision risks).

There are no further controls that are considered to provide a net benefit in reducing the likelihood or consequence of a vessel collision and subsequent release of MDO to the marine environment and thus the controls are considered to reduce the risk of diesel entering the marine environment to ALARP.

Refuelling / bunkering controls

Refuelling of the FPSO MDO storage tanks is done on an infrequent basis and is controlled through specific the NV Bunkering Operation Procedure (NV-91-IG-10006.03) which provides details on the fuel bunkering process to be undertaken and controls which include the requirement for a permit to work system to be in place and a job specific risk assessment (JSA) to be undertaken. Spill response equipment and containment devices will be on hand and their correct functioning and use is assured through spill kit inspections and spill drills performed on the FPSO and support vessels. Bunkering hoses are fitted with dry-break and breakaway couplings to limit the loss of MDO to the sea in the event of bunker hose parting, this is an industry standard considered effective in reducing the volume of MDO released to the marine environment should a spill occur.

Placement of response equipment (e.g. booms) on location (the FPSO or support vessels), ready to respond to a loss of hydrocarbons event was investigated however the cost of upkeep and the space required for the equipment was determined to be grossly disproportionate to the benefits.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos have where practicable, adopted all reasonable controls for reducing the risk.

With the above control measures in place, Santos deem that the activity risk from an unplanned surface release of MDO is ALARP.

7.9.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Residual risk is ranked as Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with OPGGS Regulations and AMSA Marine Orders. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities including the Muiron Island Marine Management Area, Ningaloo Australian Marine Park. Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015) + Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016)

	+ Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016) + Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

Given the control measures in place to prevent a MDO bunkering incident, a vessel – vessel or a vessel- FPSO collision and the low frequency of significant volume MDO spills that occur in the industry, the risk of a loss of MDO event during the activity is low. The risks from MDOs spills are well understood and the activities will be managed in accordance with relevant legislation and standards.

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect of the NV Operations

With the implementation of industry standard and activity-specific control measures to reduce the chance of an MDO spill event (and minimise impacts), the residual risk is assessed to be Low and ALARP. Control measures will reduce the risk of impact from MDO spill to a level that is acceptable.

7.10 Surface Release of Heavy Fuel Oil to the Marine Environment

7.10.1 Description of Event

Event	The following scenario could result in an HFO release to the surface: 1. A surface release of HFO from the offtake tanker as a result of external impact (vessel collision) which ruptures an HFO tank on the offtake tanker A collision event may occur between the offtake tanker and a support vessel or an errant vessel within the operational area potentially rupture an HFO tank. While the offtake tanker could potentially collide with the FPSO during berthing, the offtake tanker aligns with the FSPO into the prevailing wind/current during this process and therefore only the bow of the offtake tanker (which does not house HFO tanks) could be impacted from collision. An impact between the offtake tanker and FPSO during berthing that could rupture a lateral HFO tank on the offtake tanker is not considered credible.

	A combined typical maximum HFO inventory of 1,900 m^3 exists in the offtake tanker HFO tanks, with the largest HFO tank having a capacity of 950 m^3. The maximum credible release from this event is therefore 950 m^3 over 1 hour. It is not credible that the total storage volume of the offtake tanker would be lost, as fuel is stored in more than one tank. *The above scenario is only within the scope of the EP whilst the tanker is connected to the FPSO and carrying out a crude offtake.*
Extent	Stochastic modelling determined that the hydrocarbon extent based on moderate exposure values (**Section 7.5.5**) is: + Surface oil may occur out to 210 km from the release location. + Dissolved hydrocarbons are highly local to the release. + Entrained hydrocarbon may occur out to 240 km from the release location + Shoreline accumulation may occur at two HEVs, the furthest being Ningaloo Coast North, approximately 40 km from the release location.
Duration	**1** hour. Loss is instantaneous through the ruptured tank.

7.10.2 Nature and Scale of Impacts

Hydrocarbon spills will cause a decline in water quality and may cause chemical (e.g. toxic) and physical impacts to marine species (e.g. coating of emergent habitats, oiling of wildlife at sea surface). The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (i.e. extent, duration) and sensitivity of the receptor.

Potential receptors: Shallow benthic, intertidal and shoreline habitats; plankton; invertebrates; fish; marine mammals; marine reptiles; birds (seabirds and shorebirds); fisheries; oil and gas industry; tourism; KEFs; and State and Commonwealth marine reserves and Australian Marine Parks.

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in Table 7-15 and potential impacts to receptors found within the EMBA are further described **Table 7-16**.

7.10.2.1 Hydrocarbon Weathering Behaviour

HFO is a heavy, persistent oil with low rates of evaporation from the surface slick. There is little difference in the weathering of the surface slick for wind speeds of 1 and 5 m/s, with extremely low (~1%) proportions of evaporated and dispersed oil after 120 hours. Under high winds of 10 m/s, a maximum evaporative loss of 2% is predicted after 120 hours (**Figure 7-7)**. The primary weathering method under strong winds is dispersion into the water column, which represents 40% of the released mass after 120 hours (GHD, 2019).

The low rates of evaporation and dispersion of the surface slick are due to HFO’s initial high proportion of non-volatile components, as well as its tendency to form stable emulsions. With wind speeds of 5 m/s or higher, the surface slick is predicted to contain 75% water content by 96 hours (4 days) (**Figure 7-7)** following the release (GHD, 2019).

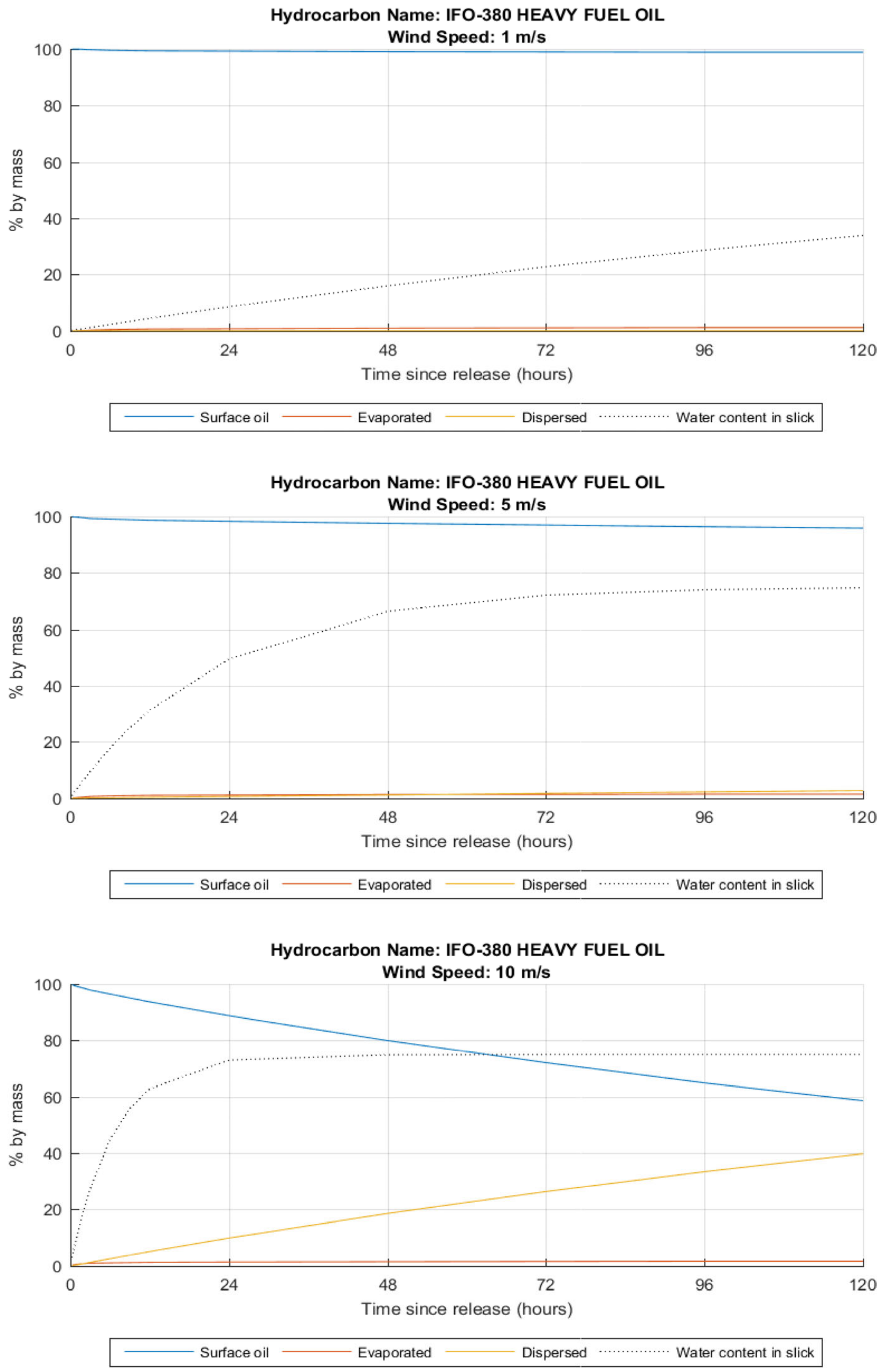

Figure 7-7: Simulated weathering of the SINTEF IFO-380 heavy fuel oil hydrocarbon for constant wind speeds of 1 m/s (top), 5 m/s (middle) and 10 m/s (bottom)Spill Modelling Results (GHD, 2019)

7.10.2.2 Spill Modelling Results

To determine the spatial extent of impacts from a potential surface release of HFO, and the dispersion characteristics over time, modelling was completed by GHD (GHD, 2019). A volume of 950 m^3 released over 1 hours was modelled at the FPSO surface location. HFO weathering behaviour modelling was undertaken by APASA (APASA, 2013b).

Modelling results have been provided for each of the four hydrocarbon fates: shoreline accumulation; surface; dissolved and entrained.

The modelling results are presented for the fate of hydrocarbon at the exposure values defined in **Section 7.5.5.** has been provided for the purposes of risk evaluation, displaying the following parameters:

+ Minimum time to contact from moderate and high exposure value;
+ Maximum hydrocarbon concentration from high exposure value;
+ Maximum oil accumulation on shoreline from moderate and high exposure value; and
+ Length of shoreline oiled.

Further parameters required to inform spill response strategies are described further in the NV Operations OPEP (TV-00-RI-00003.02).

Surface Oil

Low

Stochastic modelling determined that surface oil at concentrations equal to or greater than 1 g/m^2 could extend up to 300 km from the release location. HEVs with the potential to be contacted at the low exposure value are:

+ Muiron Islands;
+ Ningaloo Coast North;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Moderate and High

Stochastic modelling determined that surface oil at moderate exposure value of 10 g/m^2 may occur out to 210 km from the release location. HEVs with the potential to be contacted at the moderate exposure value are:

+ Ningaloo Coast North;
+ Outer Ningaloo Coast North;
+ Outer NW Ningaloo; and
+ Offshore Ningaloo.

Surface oil at the high exposure value of 50 g/m^2 may occur out to 200 km from the release location and contact Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo.

Dissolved Hydrocarbons

Stochastic modelling determined that dissolved hydrocarbons at concentrations of 10 ppb and above were not exceeded.

Entrained hydrocarbon

Low

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 10 ppb may occur out to 500 km from the release location.

Moderate and High

Stochastic modelling shows that entrained hydrocarbon with concentrations exceeding 100 ppb may occur out to 240 km from the release location. At the moderate exposure value of 100 ppb there is greater than 1% probability of entrained hydrocarbon reaching four HEVs: Ningaloo Coast North, Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo. Outer Ningaloo Coast North, Outer NW Ningaloo and Offshore Ningaloo HEVs may also be contacted at the high exposure value of 500 ppb.

Shoreline Accumulation

Low

Shoreline accumulation above the low exposure value of 10 g/m^2 may occur at four HEVs with the furthest from the release location being Outer Shark Bay Coast, approximately 600 km from the release location.

Moderate and High

Shoreline accumulation above the moderate exposure value of 100 g/m^2 may occur at two HEVs:

+ Muiron Islands; and
+ Ningaloo Coast North.

Shoreline accumulation above the high exposure value of 1,000 g/m^2 may also occur at both of these islands.

Table 7-32: Summary of Hydrocarbon Contact with Receptors: 950 m^3 Surface HFO Release

Receptor	Receptor Type	Minimum time to contact (days)							Maximum hydrocarbon concentration							Maximum oil ashore (tonnes)	Maximum length of oiled shoreline (km)
		Moderate exposure values				High exposure values			Moderate exposure values				High exposure values				
		Shoreline accumulation 100 g/m^2	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (25 g/m^2)	Shoreline accumulation (100 gm^2)	Surface hydrocarbons (10 g/m^2)	Dissolved hydrocarbons (50 ppb)	Entrained Hydrocarbons (100 ppb)	Dissolved hydrocarbons (400 ppb)	Shoreline accumulation (1000 g/m^2)	Surface hydrocarbons (25 g/m^2)	Shoreline accumulation (100 g/m^2)	Shoreline accumulation (100 g/m^2)
Montebello Islands	Emergent	14	NC	NC	NC	NC	NC	NC	194	NC	NC	NC	NC	NC	NC	2	6
Barrow Island	Emergent	13	NC	NC	NC	NC	NC	NC	357	NC	NC	NC	NC	NC	NC	6	14
Muiron Islands	Emergent	2	NC	NC	NC	NC	NC	NC	760	NC	NC	NC	NC	NC	NC	13	11
Ningaloo Coast North	Emergent	2	3	NC	3	NC	2	NC	13,697	21	NC	268	NC	13,763	NC	425	110
Outer Ningaloo Coast North	Intertidal	NA	<1	NC	<1	NC	NC	<1	1,822	174	NC	497	NC	1,938	172	NA	NA
Ningaloo Coast South	Emergent	6	NC	NC	NC	NC	6	NC	NC	NC	NC	NC	NC	NC	NC	62	88
Outer Shark Bay Coast	Emergent	17	NC	NC	NC	NC	NC	NC	112	NC	NC	NC	NC	NC	NC	1	3
Outer NW Ningaloo	Submerged	NA	<1	NC	<1	NC	NC	<1	NC	223	NC	741	NC	NC	223	NA	NA

Offshore Ningaloo	Submerged	NA	<1	NC	<1	NC	NC	<1	NC	443	NC	892	NC	NC	443	NA	NA

NC = no contact

NA = not applicable

7.10.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-10].

The control measures considered for this event are shown below (**Table 7-33**) EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-33: Control Measures Evaluation for a Surface Release of HFO

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
NV-CM-77	Berthing and Terminal Handbook (TV-22-IG-00067)	The Berthing and Terminal Handbook (TV-22-IG-00067) provides details for safe approach (e.g. daylight hours, speed, pilot accreditation) and berthing of the offtake tanker to the FPSO, reducing potential for release in the event of collision. The Berthing and Terminal Handbook also defines parameters (e.g. metocean) for offtake to occur and reducing risk of release events. Offtake tankers are subject to acceptance criteria stated in the Berthing and Terminal Handbook, which is used to assess the suitability of the proposed Offtake tanker to comply with the equipment and operational procedures developed to ensure safe offtake. This process also vets offtake tankers against the Oil	Personnel costs associated with ensuring procedures are in place, up to date and implemented.	**Adopted** – benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Companies International Marine Forum (OCIMF) guidelines. Vetting offtake tankers against these guidelines ensures best practice is followed during offtake and approach and reduces the likelihood of a release occurring.		
NV-CM-78	Offtake Operations and Pilotage Procedure (NV-91-IG-10010.03)	FPSO will complete a pre-berthing toolbox talk before each offtake which includes a check of the key controls, functioning equipment and communication, which mitigate against vessel to vessel interaction and loss of containment incidents.	Personnel costs associated with ensuring procedure is in place, up to date and implemented.	**Adopted** – benefits of ensuring procedure is followed and measures implemented outweigh the costs of personnel time.
NV-CM-19	Seafarer Certification	Requires appropriately trained and competent personnel, in accordance with Marine Order 70 (vessels) and IMO standards of training, certification and watch-keeping (STCW) (offtake tanker and FPSO), to navigate vessels to reduce interaction with other marine users.	Costs associated with personnel time in obtaining qualifications.	**Adopted -** benefits considered to outweigh costs and is a legislated requirement.
NV-CM-18	Navigation lighting and aids	Reduces risk of environmental impact from vessel collisions due to ensuring safety requirements are fulfilled and other	Negligible costs of operating and maintaining navigational equipment.	**Adopted** – Benefits considered to outweigh negligible costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		marine users are aware of the presence FPSO, offtake tanker and vessels.		
NV-CM-80	Radio communication prior to entering PSZ	Allows for communication to be established between vessels and the FPSO prior to entering the PSZ which reduces vessel to vessel interaction and the risk of collision, releasing hydrocarbons.	Negligible costs involved in communicating presence.	**Adopted** – Benefits considered to outweigh negligible costs.
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km, is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-66	Oil Pollution Emergency Plan (OPEP)	Implements response plan to deal with an unplanned hydrocarbon spills quickly and efficiently in order to reduce impacts to the marine environment.	Personnel and administrative costs associated with preparing documents, ongoing management (spill response exercises) and implementation of OPEP.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.
NV-CM-67	Incident Response Plan detailing the	Provides detail to ensure the ESD system is activated quickly and efficiently	Administrative costs of preparing documents.	**Adopted** – Benefits considered to outweigh costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
	requirements for preparedness and response to emergencies and crises to protect people and the environment.	if it has not automatically activated, to reduce the extent of impacts to the marine environment.		
NV-CM-59	Vessel spill response plan (SOPEP/SMPEP)	Implements response plans on board vessels to deal with unplanned hydrocarbon releases and spills quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents. Generally undertaken by vessel contractor so time for Santos personal to confirm and check SOPEP/SMPEP in place.	**Adopted** – Benefits considered to outweigh costs.
Additional control measures				
N/A	Contracting a standby vessel 24 / 7 during NV operations to aid in the detection of approaching third party vessels.	Standby vessel to monitor the 500 m PSZ and be equipped with an Automatic Identification System (AIS) to aid vessel detection at sea, and radar to aid in the detection of approaching third party vessels. Reduces risk of vessel collision and subsequent unplanned release of hydrocarbons causing potential harm to the marine environment.	High cost associated with contracting standby vessel. Negligible costs of operating navigational equipment. Additional risks from vessel in the 500 m PSZ.	**Rejected** – Large cost associated with dedicated standby vessel on location deemed grossly disproportionate compared to low risk of large HFO spill. Additional risks exist from vessel use.
N/A	Double hull around bunker tanks on an offtake tanker	Minimises the potential of an HFO spill from tanker if impact occurs.	Santos does not own offtake tankers, and there is no maritime regulatory requirement for double hull around bunker tanks on offtake tankers.	**Rejected –** Unreasonable requirement of offtake tanker given the low likelihood of event.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
N/A	Pipeline the crude oil to the mainland	Construction and installation of a pipeline to mainland would negate the requirement for offtake tanker presence, therefore remove collision risk and offtake release risk and subsequent crude release to the environment.	Significant costs involved in constructing, installing and operating a pipeline. Additional environmental costs associated with construction and installation of a pipeline as well as crude release risks associated with transporting the crude	**Reject** – Costs which grossly outweigh the environmental benefit.
N/A	Limiting offtake frequency	Limiting offtake frequency will reduce likelihood of unplanned releases as less offtakes will be undertaken	Significant financial cost as production would have to decrease	**Reject** – Costs which grossly outweigh the environmental benefit
N/A	Reducing loading rates	Reducing load rates has the potential to reduce the volume discharge should there be an integrity failure in the offtake equipment	Significant financial cost, as offtakes will take longer. Additional risks involved with the tanker remaining on location.	**Rejected** – Risk of integrity failure is rare. Costs which grossly outweigh the environmental benefit and risk. Rates for offtake given in the Berthing and Terminal Handbook and monitored during loading.
N/A	Only accepting tankers that have previous experience successfully loading from NV	Only accepting tanker which have previous experience loading from NV provides additional assurance that the offtakes can be completed successfully.	Significant financial cost, as offtake tanker availability will be constrained. Production may be decreased whilst waiting for suitable offtake tanker.	**Rejected** – Costs which grossly outweigh the environmental benefit and risk.
N/A	Only accept offtake tanker which uses MDO	Should a release occur marine diesel will cause less impact to the marine environment compared to HFO, largely due to its	Significant cost implications as would limit the amount of offtake tankers able to berth and offtake Van Gogh crude blend. Majority of	**Reject -** Costs which grossly outweigh the environmental benefit. Majority tankers use HFO. Santos

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		rapid evaporations and lower volatiles.	offtake tankers use HFO. Offtake frequencies may be limited whilst Santos find suitably fuelled offtake tankers. Production may have to reduce, leading to significant costs.	cannot control what the offtake tankers use for fuel. Only accepting marine diesel tankers would limit the offtake frequencies.

7.10.4 Environmental Impact Assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.6**.

7.10.4.1 Identification of Hotspots for Consequence Analysis

As described in **Section 7.5.6**, all HEVs within the EMBA (low exposure value) are listed in Table 7-34 below. The values and sensitivities associated with these HEVs have been described in **Appendix D1.** Further to this, Table 7-34 filters the HEV to identify the hotspots where they meet the criteria in also described in **Section 7.5.6**

Table 7-34: Identified High Environmental Value and Hotspot Receptors

Receptor	HEV Value	Exposure Value			Hotspot*
		Low	Moderate	High	
Ningaloo Coast North	3	✓	✓	✓	✓
Outer Ningaloo Coast North	3	✓	✓	✓	
Muiron Islands	2	✓	✓		
Montebello Islands	3	✓	✓		
Barrow Island	3	✓	✓		
Ningaloo Coast South	3	✓	✓	✓	
Outer NW Ningaloo	3	✓	✓	✓	✓
Montebello AMP	4	✓			
Offshore Ningaloo	4	✓	✓	✓	✓
Outer Shark Bay Coast	3	✓	✓		

* greater than 5% probability of contact

This process identified the following hotspots:

+ Ningaloo Coast North; and
+ Outer NW Ningaloo.

Table 7-20 provides a simplified summary of the consequence assessment results for each of the Hotspot areas. The consequence assessment was based on predicted contact and concentration of surface oil, accumulated oil, entrained hydrocarbon and dissolved hydrocarbons. For each Hotspot area the consequence to the key values were assessed using the methodology described in **Section 7.5.6**.

7.10.4.2 Release of HFO from offtake tanker storage tank from a loss of integrity or impact

Receptors	Threatened, migratory, and local fauna Protected areas Physical environment and habitats Socio-economic receptors
Consequence	III - Moderate

Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-15** and potential impacts to receptors are described in **Table 7-16**.

Threatened, migratory, and local fauna

HFO is persistent at the sea surface and shows little entrainment under the sea surface but a gradual decrease in volume over time from evaporation and decay (biodegradation). Surface oil, and entrained hydrocarbon in the sea surface layer, could have the physical effect of coating fauna interacting within and under the surface, including plankton, pelagic invertebrates and fishes, marine reptiles, marine mammals and seabirds, and may also cause slight secondary effects through ingestion after preening for seabirds, or through ingestion of oiled fish.

Chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (**Table 3-8**). Habitat modification/degradation/disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Long-term impacts resulting in complete habitat loss or degradation are not considered likely with control measures proposed to prevent releases.

The humpback whale (migration and resting) and pygmy blue (distribution, migration and foraging), BIAs overlap the moderate exposure value area. An unplanned release of HFO is not expected to interfere with their migration activity. There is the potential for behavioural disruption to the local population as individuals traverse the release.

Deteriorating water quality / chemical and terrestrial discharge is identified as a potential threat to turtles in the marine turtle recovery plan, and some bird and shark species (**Table 3-8**). Habitat modification, degradation and disruption, pollution and/or loss of habitat are also identified as threats to sharks, birds, cetaceans and turtles in conservation management and recovery plans. Given the location of the release, and volume of potential hydrocarbon release there is the potential for modification to or a decrease in the availability of quality habitat (shorelines/subsurface), particularly given the volumes of accumulated hydrocarbons (maximum volume of hydrocarbon accumulation is at Ningaloo Coast North – 425 tonnes) and persistence of HFO. Shoreline accumulation may present a major disruption to shoreline individuals (as described in **Table 7-16**). Volumes of accumulated hydrocarbon may result in a major reduction in area available for seabirds and/or turtles species. The quality of habitat (shorelines/subsurface) may be reduced for a period, with recovery over the medium term (2 – 10 years).

The Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves states that DPaW should 'Ensure that important seabird and shorebird breeding and feeding areas are not significantly affected by human activities. The potential impacts of a hydrocarbon release on seabird breeding and feeding areas are discussed in **Table 7-16.** Impacts in relation to human activities from responding to a spill are described in **Section 6.8**.

Physical Environment and Habitats

In the event of HFO release, hydrocarbons that reach nearshore environments have the potential to impact benthic coral reefs and mangrove areas which may result in a long-term decrease in ecological values given toxicity impacts associated with hydrocarbon exposure. The quality of habitat may be reduced for a significant period with recovery over the medium term (2 – 10 years).

Stranded hydrocarbons on shorelines could impact marine fauna that utilise beaches such as shorebirds and turtles, dependent upon the timing of a spill. Beaches on the Ningaloo Coast are important for green turtles, and to a lesser extent hawksbills turtles. Impacts to turtles could occur from surface hydrocarbons if oil accumulated on nesting beaches. Entrained hydrocarbon could also contact sandy beaches at high

tide. Such impacts would be most likely to nesting females as they move up and down beaches or to turtle hatchlings as they emerge from nests 6-8 weeks following nesting. Protected areas The moderate exposure value area intersects several protected areas and AMPs and marine management areas (impacts discussed in **Table 7-16** and AMP details presented in **Section 3.2**). Combined, these areas support all the habitats and faunal groups described above. Impacts to the habitat/fauna receptors described in **Table 7-16** and impact on the values of these reserves could have flow-on effects to tourism revenue of coastal communities that provide access to these marine reserves. Many of these receptors are values of protected areas and there could be a significant impact on them. Socio-economic receptors There is the potential for hydrocarbons to temporarily disrupt fishing activities if the surface or entrained hydrocarbon moves through fishing areas. A major spill would result in the establishment of a safety exclusion zone around the affected area. A temporary prohibition on fishing activities for a period of time may be required, and subsequently there is a potential for economic impacts to those affected. Hydrocarbon may also foul fishing equipment which will require cleaning or replacement. Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Fish have a high capacity to metabolise these hydrocarbons, while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). 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 (Yender et al. 2002). Heritage values are not predicted to be impacted by surface oil although in the short-term there would be an impact on the aesthetic value of the area. A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. A large surface HFO spill has the potential to disrupt these activities, with associated economic impact, albeit on a temporary basis. Tourism could be affected by spilled HFO, either from reduced water quality/shoreline oiling preventing recreational activities or reducing aesthetic appeal or from impacts to habitats and marine fauna. On the basis of the above assessments, a loss of HFO from the offtake tanker tank rupture has the potential to impact an array of receptors. Given the extent, the worst-case consequence is considered to be Moderate (III).	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case surface release of HFO from the offtake tanker a result of external impact (vessel collision) has been defined as a 'Remote' event as it ' requires exceptional circumstances and is unlikely even in the long term'. External impacts to the offtake tankers carrying out transfers within the operational area have not occurred within Santos. Controls are in place which limit third party vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy), which includes the offtake tanker when undertaking crude transfers. The operational area is also a significant distance (40 km) from major shipping routes and significant fishing effort and associated vessels have not been reported within the operational area since NV production began. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case surface release of HFO from the offtake tanker as a result of external impact (vessel collision) resulting in a *Moderate (III)* consequence is considered to be *Remote.*	
Residual Risk	The residual risk associated with this event is **Very Low**

7.10.5 Demonstration of ALARP

Vessel activities are required to maintain the functioning of the FPSO and cannot be eliminated. The FPSO is marked on Australian Hydrographic Service Nautical Charts which identifies the location of the FPSO and offtake tanker berthing activities to other sea users. Collision prevention equipment (i.e. navigation and radio equipment) and seagoing qualifications used on vessels/FPSO/offtake tankers will comply with applicable AMSA Marine Orders / MARPOL requirements.

Contracting a standby vessel to monitor the 500 m PSZ was investigated as it has potential to reduce risk of errant vessels entering the PSZ and colliding with the offtake tanker. However significant cost associated with having dedicated standby vessel on location is disproportionate compared to the environmental benefit and low risk of a vessel collision.

Further to standard collision prevention measures used by all vessels, procedures outlined in the Berthing and Terminal Handbook (TV-22-IG-00067) provide controls to reduce the risk of collision during offtake tanker berthing and crude oil cargo loading. These handbook procedures are communicated to acknowledged and accepted by the Offtake Tanker Master prior to entering the operational area. Berthing activities completed by a specialised Pilot. **Section 7.8.5** provides further details on ALARP demonstration for controls within the Berthing and Terminal Handbook (TV-22-IG-00067).

Table 8-2 details the Performance Standards relating to the NV-CM-75 Berthing and Terminal Handbook (TV-22-IG-00067).

Additional controls such as removing the requirement for offtake tankers through installation of a pipeline to mainland and limiting offtakes through reducing production present significant costs and grossly outweigh the environmental benefits, as described in **Table 7-33**. The acceptance of third-party offtake tankers is regulated by Santos through the use of the criteria detailed within the Berthing and Terminal Handbook (TV-22-IG-00067), as described above and **Section 7.8.5**, and provides assurance that the offtake tanker meets specified criteria and will comply with the Berthing and Terminal Handbook (TV-22-IG-00067).

Support, project vessel and offtake tanker movement within the operational area is coordinated from the FPSO with permission needed for entry into the 500 m PSZ; this reduces the potential for collisions if SIMOPS are occurring.

There are no further controls that are considered to provide a net benefit in reducing the likelihood or consequence of a vessel / offtake tanker collision and subsequent release of HFO to the marine environment and thus the controls are considered to reduce the risk of diesel entering the marine environment to ALARP

Placement of response equipment (e.g. booms) on location (the FPSO or support vessels), ready to respond to a loss of hydrocarbons event was investigated however the cost of upkeep and the space required for the equipment was determined to be grossly disproportionate to the benefits.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos have where practicable, adopted all reasonable controls for reducing the risk.

With the above control measures in place, Santos deem that the activity risk from an unplanned release of HFO is ALARP.

7.10.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes – Residual risk is ranked as Very Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat	Yes – Management consistent with OPGGS Regulations and AMSA Marine Orders. Santos has considered the values and sensitivities of the receiving environment including, but not limited to:

abatement plans, conservation advice and Australian marine park zoning objectives)?	+ Conservation values of the identified protection priorities including the Muiron Island Marine Management Area, Ningaloo Australian Marine Park. Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015) + Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016) + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016) + Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

Given the control measures in place to prevent a vessel- offtake tanker collision the risk of a loss of containment event during the activity is very low. The risks from HFOs spills are well understood and the activities will be managed in accordance with relevant legislation and standards.

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect of the NV Operations

With the implementation of industry standard and activity-specific control measures to reduce the chance of an HFO spill event (and minimise impacts), the residual risk is assessed to be Very Low and ALARP. Control measures will reduce the risk of impact from HFO spill to a level that is acceptable.

7.11 Subsea Release of Dry Gas to the Marine Environment

7.11.1 Description of Event

<table>
<tr><td>Event</td><td>
An unplanned release of dry gas is considered credible from a gas well or from the gas subsea system.
Gas Well
The following scenarios could result in subsea dry gas releases from the gas wells:
<table>
<tr><th>No.</th><th>Scenario</th><th>Maximum credible volume</th></tr>
<tr><td>1</td><td>Subsea dry gas release from a gas production well or gas injector/producer as a result of external impact (such as anchor /chain drag)
(TNF, NV-22-II-20001)</td><td>233 MMscfs dry gas over a 100 day period</td></tr>
<tr><td>2</td><td>Subsea dry gas release from a gas production well or gas injector/producer as a result of loss of integrity from internal influences (such as loss of integrity from corrosion/erosion, fatigue cracking, over/under pressure and cementing/seal failures)
(TFN – G1 (VGA4) Credible Gas Release Rates Dated 9/11/2018)</td><td>77 MMscf over a 100 day period</td></tr>
</table>
1. Subsea dry gas release from a gas production well or gas injector/producer as a result of external impact (such as anchor /chain drag)
During extreme cyclone conditions it is possible that a MODU working for an operator of an adjacent field breaks loose from its mooring and drifts over the location of the Van Gogh, Coniston and Novara subsea wells.
If the drifting MODU drags an anchor and / or anchor chains over the seabed then it is possible that they latch on to or wrap over a subsea tree of a production well connected to the NV FPSO, thus imparting a substantial force on the wellhead, tree and completion.
If a MODU chain or anchor were to apply sufficient bending moment on the wellhead, the wellhead could bend at the soft mudline until it is aligned with the direction of the pulling force. Should the force implied by the drifting MODU continue to increase above the yield strength of the chain, the chain will fail. That is, the anchor chains on the MODUs operating in the vicinity of NV Operations do not have strength required to separate the wellhead and the subsea tree off the well. It follows that since the wellhead and subsea tree remain in place, an uncontrolled release of well fluids through a full-bore blowout is not a credible scenario.
The above could result in a maximum release of approximately 2.33 MM scf/d, (347,501sm^3 or 258,819 kg) or 233 MMscfs dry gas over a 100 day period, which is the worst case credible scenario for the unplanned release of subsea dry gas.
2. Subsea dry gas release from a gas production well or gas injector/producer as a result of loss of integrity from internal influences (such as loss of integrity from corrosion/erosion, fatigue cracking, over/under pressure and cementing/seal failures)
The loss of integrity through an internal influence resulting in a leak in the 9-5/8" casing above the production packer (A-annulus), which has resulted in a degraded secondary barrier envelope. The G1 well is operating under a single barrier dispensation in accordance with the QE Well Integrity Management Guidelines: Well Integrity for the Operational Phase (QE-91-IW-00002).
Under this scenario the gas release can occur upon failure of all of the following well barriers:
+ Compromised integrity of the production casing below the production packer. Gas leaks through a 0.55” inch equivalent diameter breach in the casing wall.
</td></tr>
</table>

- Failed cement bond of the 9 5/8 inch) production casing. Gas flows between the casing and the cement through a 0.1” gap (1.39 inch equivalent diameter).
- Gas reaches the top of cement of the 9 5/8 inch casing and enters the 13 3/8 inch casing annulus.
- Gas flows in the annulus, between the 13 3/8 inch, 68 ppf casing (12.415 inch ID) and the 95/8 inch OD production casing (3.98 inch equivalent diameter).
- Compromised integrity of the 13 3/8 inch casing and cement bond. Gas escapes into the environment at the midline, below the wellhead through 0.55 inch breach in the casing wall.

As such, the worst case credible leak release from internal influences on a gas production well is 0.77 MMscf/day which equates to a loss of approximately 77 MMscf over a 100 day period.

Gas Subsea System

An unplanned release of gas could potentially occur from the gas subsea system (e.g. componentry such as a gas flowline or equipment such as gas lift jumpers).

The following scenarios could potentially result in subsea dry gas releases from the gas flowline:

No.	Scenario	Maximum credible volume
1	Subsea release of dry gas from the gas flowline as a result of external impact (anchor /chain drag, dropped object). (TFN –NV-22-II-20002)	84,790 scm/hour
2	Subsea dry gas release from a gas flowline as a result of loss of integrity from internal influences (such as loss of integrity from corrosion/erosion, fatigue cracking, over/under pressure and cementing/seal failures). (TFN – NV-22-II-20002)	Large: 468,336 kg/day Medium: approximately 672kg/day Small: approximately 1kg/day

1. Subsea release of dry gas from the gas flowline as a result of external impact (anchor /chain drag, dropped object).

External impact due to a dropped object may occur during inspection, maintenance and repair activities or during infill drilling activities (which would be subject to a separate EP). In this event an automatic detection of the leak will occur, the safety valves will automatically close and stop the release. This would result in a maximum daily flow rate for 1 hour resulting in a complete loss of volume of gas in the pipeline.

The calculated release volume for a release from a gas flowline is based on the AMSA (2013 Guideline: Technical Guideline for the preparation of marine pollution contingency plans for marine and coastal facilities) which assesses the maximum flow rate and release for 1 hour. The volume is greater than the gas production well loss scenario rate (approximately 84,790 scm/hour, see above) but is only released for a period of one hour.

The following scenarios could result in subsea dry gas releases from subsea equipment such as the gas lift jumper:

2. Subsea dry gas release from the subsea gas system (e.g. componentry such as gas lift jumpers) as a result of loss of integrity from internal influences (such as loss of integrity from corrosion/erosion, fatigue cracking, over/under pressure and seal failures).

Three volumes for unplanned gas releases from the gas lift jumpers are outlined below:

- Large instantaneous leak due to complete hose rupture or coupling separation resulting in approximately 468,336 kg/day to be released from Coniston and Novara Drill Centres, or approximately 81,456 kg/day, from the Van Gogh Drill centres. Leak would be immediately shut-in.

	+ Medium size leak due to partial integrity failure of gas lift jumpers causing bubbles to escape over an extended period (approximately 672kg/day). Leak would be immediately shut-in + Small size leak equivalent to fugitive bubbling of gas from the carcass of subsea infrastructure (approximately 1kg/day). The maximum release of dry gas remains as 2.33 MM scf/d, (347,501sm^3 or 258,819 kg) or 233 MM scfs over a 100 day period.
Extent	In the event of an unplanned release of dry gas impacts would be highly localised.
Duration	100 day release duration for detected leak based on duration to control the well leak. The release period is based on a conservative rig mobilisation and relief well drilling schedule. In the event of a leak from the subsea gas system leak would typically be immediately shut-in through ESD. In the event of a small leak from the subsea system or well (below NV control room detectable levels) as a result of internal influence or external impact, it is credible that the leak is undetected for a period until periodic IMMR inspection by ROV (e.g. A worst case scenario would be that a failure in integrity occurs immediately after one ROV survey and is not detected until the next IMMR inspection). The maximum period a release goes undetected for is 365 days (as per leak scenario in **Section 7.7.1**).

7.11.2 Nature and Scale of Environmental Impacts

Potential receptors: Plankton; invertebrates; fish; marine mammals; marine reptiles.

In the event of an accidental loss of gas containment from a subsea source, the released gas would rise towards the sea surface, passing through three distinct zones of interest (ARC, 2018) (refer also Figure 7-8): The Jet Zone, the Zone of established flow and the Zone of Surface Flow.

Jet Zone: The high velocity at the release point generates the jet zone which is dominated by the initial momentum of the gas. Water is also entrained into this zone, resulting in a rapid loss of momentum a few metres from the leak source.

Zone of Established Flow (ZOEF): In the buoyant plume zone, momentum is no longer significant relative to buoyancy, which then becomes the predominant force for the remainder of the plume. In this region the gas continues to expand due to reduced hydrostatic pressures. Although the terminal velocity of a gas bubble in stationary water is only about 0.25 m/s, velocities in the centre of release plumes can reach 5 to 10 m/s due to the build-up of momentum in the entrained bulk liquid. That is, the water surrounding the upward moving gas is entrained and given an upward velocity, which is then increased as more gas moves through at a relative velocity of 0.25 m/s.

Zone of Surface Flow (ZOSF): At the surface interaction zone the upward flow of water turns and moves in a horizontal layer away from the centre of the plume. The influence of the surface water currents cause this radial flow to turn downward forming a parabolic surface influence as seen in **Figure 7-8**. The gas exits from the centre of the plume and causes a surface disturbance or 'boil zone' identified by the arrows in the top view of **Figure 7-8.**

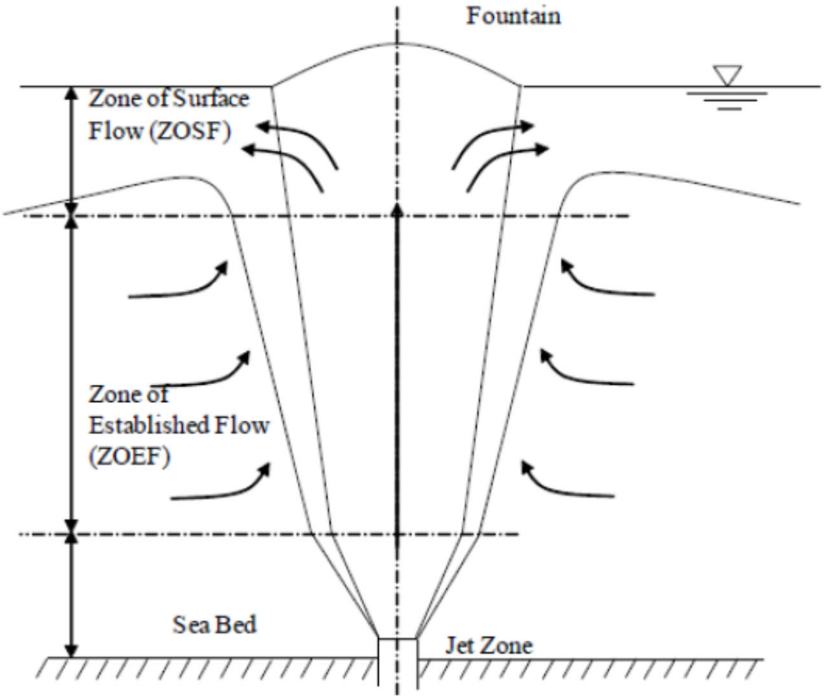

Figure 7-8: Typical underwater release with gas plume formation

The most predominate subsea plume zone is the ZOEF. The extents of the Jet Zone and the ZOSF are considered insignificant by comparison. The plume is assumed to form a simple conical shape, whereby its diameter at sea surface is related to the depth of its release.

A Subsea Release and Dispersion Assessment (Add Energy, 2016), was prepared for the Van Gogh Infill and Novara drilling campaign in 2018, which showed that the loss of containment from the gas lift flowline would results in the gas rising to the sea surface in a plume of gas bubbles that break the surface in a 'boil zone'. The boil zone would have a diameter of 72–74 m and the gas above the boil zone would disperse in the atmosphere in a buoyant plume as the gas (predominantly methane) is less dense than air. Whilst the cumulative gas released from a full loss of containment from the gas lift flowline is less than the production well dry gas release scenarios, the principles are consistent in that subsea gas release assumes the boil zone at the sea surface is a function of water depth. The diameter of the boil zone is taken to be 20% of the water depth (Add Energy, 2016), hence a diameter of 72m – 74m at 370m depth, is still applicable for a larger loss of containment.

Sea surface gas fires in the boil zone could occur (if there was an ignition source), but are unsustainable and would rapidly self-extinguish, because the significant subsea dispersion as the gas rises to the sea surface, means that the velocity of the gas-air mixture rising from the boil zone is less than the fundamental burning velocity for the gas, leading to the fire self-extinguishing.

Given the nature of the gas releases that could occur, continuous exposure to marine fauna at high concentrations is not expected as the bubbles rise towards the surface in a plume as well as dissolving in the water column before being released to atmosphere. The fraction of dissolved methane will be oxidised to carbon dioxide and water, resulting in low to non-existent toxicity on the water column.

7.11.3 Environmental Performance and Control Measures

The Environmental Performance Outcome (EPO) relating to this event is:

+ No loss of containment of hydrocarbon to the marine environment [EPO-NV-10]

The control measures considered for this event are shown below (**Table 7-18**). EPS and measurement criteria for the adopted controls are presented in **Table 8-2.**

Table 7-35: Control Measures Evaluation for a Dry Gas Release

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
NV-CM-61	Inspection of Hydrocarbon Containing Equipment	Inspection, Maintenance and Monitoring (IMM) includes inspection of hydrocarbon containing subsea systems and structures, including: + Subsea systems and structures + Static sections of flexible flowlines + Dynamic risers, dynamic umbilicals and associated mid-water buoyancy systems + Subsea Flexible Hoses + Mooring systems IMM is set in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) which provides inspection frequencies (at annual for GVI of hydrocarbon containing subsea systems and structures (including gas systems), scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment.	Costs associated with personnel time in writing, reviewing and implementing the IMM Plan. Costs associated with in field inspections (e.g. vessel use, use of ROV, personnel time).	**Adopted** – Benefits considered to outweigh costs.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Post-cyclone inspection by ROV may be able to provide additional surveillance of anomalies or areas of interest flagged by inspections or analysis.		
NV-CM-62	Production operating procedures	Procedures to ensure production operations are within the operating envelope to maintain the integrity of the subsea infrastructure. Operating within envelopes reduces dry gas release risk.	Costs associated with personnel time in writing, reviewing and implementing the procedures.	**Adopted** – Benefits considered to outweigh costs.
NV-CM-63	NOPSEMA accepted WOMP	The WOMP manages well integrity and all wells will be in compliance with the NOPSEMA accepted WOMP at all times. The WOMP includes control measures to manage well integrity risks to ALARP, including: + Barriers in place to isolate hydrocarbons from the marine environment + Inspection, monitoring and testing of barriers over the life of the well + Response to increases in well integrity risk + Notification and reporting requirements	Costs associated with personnel time in writing, reviewing and implementing the WOMP.	**Adopted** – Benefits considered to outweigh costs. Regulatory requirement must be adopted.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Effective barriers manage isolation of the reservoir from the environment, acting to eliminate hydrocarbon releases.		
NV-CM-17	Navigational charting of infrastructure	Subsea infrastructure is charted on Australian AHS Nautical Charts so other users are aware.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – the positive benefits of identifying subsea infrastructure to other marine users outweighs the process of arranging their charting with AHS.
NV-CM-16	Petroleum safety zone and cautionary area	The presence of the PSZ extended around the DTM buoy is marked on AHS Nautical Charts. Third party vessels are not permitted to enter the zone. A 2.5nm cautionary zone extends around the subsea infrastructure in order to alert other marine users. Ships must navigate with particular caution in order to reduce the risk.	No additional costs. Other marine users may be temporarily excluded from areas, disrupting their activities.	**Adopted** – risk of excluding other marine users within a 500 m PSZ and cautioning vessels to navigate with care within 2.5km, is unlikely to significantly impact upon the marine user. The benefits to safety of the activity (thus reducing risk of environmental impacts due to vessel collisions) outweighs potential costs.
NV-CM-64	Testing of ESD and blowdown systems	ESD and blowdown systems are function tested in accordance with: + PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06) + PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07)	Personnel costs associated with testing and ensuring testing takes place.	**Adopted** – benefits of ensuring testing of ESD and blowdown systems occurs outweighs the costs of personnel time.

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		+ PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). ESD and blowdown systems will detect abnormal process conditions and alert the operators to execute preventative and mitigative actions on hydrocarbon containing equipment (including wells at the Christmas Trees). Functioning and tested ESD and blowdown systems ultimately prevent / minimise release volumes and initiate blowdown and shutdown on hydrocarbon containing equipment during abnormal process, limiting any release to the environment.		
NV-CM-82	Low Pressure Alarm on Distributed Control System (DCS) for GLJ/flowline	Low pressure alarm will alert operators to significant drops in gas pressure which could indicate a leak in the subsea system, leading to timely isolation and investigation of potential leaks and minimisation of leaks to sea.	No significant cost. Cost to ensure process is followed.	**Adopted** – Benefits of ensuring procedures are followed and control measures implemented outweigh costs to Santos.
Additional control measures				
N/A	Protection and burying to protect from external impacts	Protection and burying of the flowlines and subsea infrastructure will reduce the risk of	Large cost and seabed disturbance associated with burying and protection. Burying	**Rejected** – Large cost associated with burying and protecting is disproportionate compared to the risk. May

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		dropped objects impact.	the infrastructure also causes technical inspection and maintenance activity issues.	also cause operational issues.
N/A	Real time leak detection using pressure and temperature instrumentation	Would allow detection of a leak and subsequent environmental release to be detected immediately. Well would then be shut in.	Pressure and temperature instrumentation are ineffective at detecting fugitive leaks and emissions in the subsea environment.	**Rejected** -Control is not effective at detecting fugitive leaks and emissions in the subsea environment.
N/A	Continuous ROV monitoring of subsea system	Ensures that leaks are detected quickly during visual inspection of the valves.	The cost for 24-hour monitoring in field including vessel hire would be approximately $200K/day.	**Rejected** – Cost outweighs the environmental benefit.
N/A	Drill top holes of a relief well to kill leak from gas injection well	Will allow for relief well to be drilled faster as top holes have been drilled.	Large cost associated with the MODU is estimated at $555,000 per day. Multiple top holes would be required to be drilled in the fields.	**Rejected –** MODU is approximately $555,000 per day. Drilling of top holes may cause additional environmental impact which outweighs the benefits.
N/A	MODU on standby for drilling a relief well	Will allow for relief well to be drilled immediately as MODU is on standby.	Large cost associated with the MODU is estimated at $555,000 per day.	**Rejected –** MODU is approximately $555,000 per day, the cost of having a MODU on standby is disproportionate to the environmental benefit.
N/A	Testing of ESD and blowdown systems at greater frequency than that detailed by PSAPs	Little environmental benefit. PSAP approach determines function testing and inspection frequency. Frequency may be greater based on a risk based approach (e.g. inspections or analysis results) which indicate further testing and inspection is required.	Costs associated with testing of ESD and blowdown systems at greater frequencies	**Reject** – Costs which grossly outweigh the environmental benefit. Unwarranted function testing and inspection greater than that of a risk based PSAP risk based approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to

Reference No	Control measure (CM)	Environmental benefit	Potential cost/issues	Evaluation
		Unwarranted testing is determined to provide little to no integrity assurance benefits.		grossly outweigh environmental benefit

7.11.4 Environmental Impact Assessment

The following individual scenarios (as defined in **Section 7.11.1**) leading to a subsea release of dry gas have been risk assessed in the below sections:

+ Subsea dry gas release from a gas well as a result of external impact (rupture scenario)
+ Subsea dry gas release from a gas production well or gas injector/producer as a result of loss of integrity from internal influences
+ Subsea dry gas release from the gas subsea system (e.g. gas flowline or componentry such as a gas lift jumper) as a result of loss of integrity from internal influences (such as loss of integrity from corrosion/erosion, fatigue cracking, over/under pressure and cementing/seal failures) (leak scenario)
+ Subsea release of dry gas from the gas subsea system as a result of external impact (anchor /chain drag, dropped object)

7.11.4.1 Subsea dry gas release from a gas well as a result of external impact

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor

<u>Physical Environment and Habitats</u>

Given the nature of the gas releases that could occur, continuous exposure to marine fauna at high concentrations is not expected as the bubbles rise towards the surface in a plume as well as dissolving in the water column before being released to atmosphere.

The gas is approximately 90% Methane (classified as non-toxic and non-hazardous), 9% nitrogen and 1% carbon dioxide. Methane is not readily water soluble and so will not saturate the water column, instead rising rapidly to release to the atmosphere at the sea surface rather than being trapped at depth in the water column. Dry gas is not persistent on the surface.

In sea water in the presence of oxygen, methane oxidises to carbon dioxide and water (H2O). However, in a pipeline rupture, approximately 85 percent of the CH4 released will reach the atmosphere, as the fraction oxidised in the water column amounts to 5 to 15 percent (Ward et al., 1987).

<u>Threatened, Migratory, and Local Fauna</u>

Receptors occurring within the subsea plume from the gas release could be impacted – within a radius of 10's of metres from the release site. These receptors may include pelagic fish, marine invertebrates and marine mammals. Benthic receptors would not be affected as the gas bubbles rise to the surface.

Studies on the impacts of methane on fish have shown that a behavioural response can be elicited through continuous exposure such as increased activity and scattering within the water (avoidance behaviour). Continuous exposure at high concentrations can lead to toxic impacts but is dependent on the exposure time, environmental conditions and the nature of the toxicant (Patin, 1999).

Patin (1999) also notes that "Further exposure leads to chronic poisoning. At this stage, cumulative effects at the biochemical and physiological levels occur. These effects depend on the nature of the toxicant, exposure time, and environmental conditions. A general effect typical for all fish is gas emboli. These emerge when different gases (including the inert ones) oversaturate water". However, in this credible worst

case scenario the methane component is not readily water soluble and therefore will not saturate the water, given the deep open ocean environment. Low-oxygen conditions caused by methane-consuming microbes, could potentially threaten small marine organisms such as plankton, fish larvae, and other creatures that can't roam large distances. A small component of gas may remain in the waters occupied by and surrounding the gas plume. However, 'trapping/saturation' of the gas and significant oxygen depletion (and subsequent impacts to marine life) is not expected to occur given the surrounding waters are generally well mixed. Given the nature of the gas releases that could occur in field, continuous exposure at high concentrations is not expected as the bubbles rise towards the surface in a plume as well as dissolving in the water column before being released to atmosphere. The fraction of dissolved methane will be oxidised to carbon dioxide and water, resulting in low to non-existent toxicity on the water column. Therefore, the gas would not saturate the water in the immediate vicinity of the release where the majority of potential receptors are concentrated (assuming fauna are present in the immediate area due to a possible attraction to the infrastructure). Rapid dissipation of the bubbles as they rise to the sea surface will also occur. Therefore, toxicological impacts are not expected, but if toxic impacts did result, this would be to individuals in the immediate vicinity of the plume and would be no more than a minor impact. There are BIAs (for migratory blue whale, humpback whale and seabird species that overlaps with the operational area. However, the areas are not feeding or aggregation grounds and the expectation is that these spices would be transiting the area. The BIA area is far larger than the operational area and so the species are able to avoid the localised impact area if needed. Given the transient nature of marine mammals through the deep water open ocean area, no significant impacts on marine mammals would be expected. Whilst behavioural impacts (avoidance of the area) may result from the release of bubbles, physiological impacts are not expected and the impact on behaviour is considered minor. The gas release will dissipate quickly within the water column. Regardless of the volume of gas released it is expected that this will result in a minor consequence as the environmental effects would last for weeks to less than 12 months, with short term behavioural impacts to a small proportion of the local population, with no impact on the physical environment, habitat or its function. A discharge of this nature would result in a *Minor (II)* consequence.	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of dry gas from a production well has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term'. This likelihood is further supported by industry statistics between January 1980 through 31 December 2014, which show that a loss of well containment for production wells from an external events is 5.1% of all blowouts recorded within the area of study (Gulf of Mexico and North Sea) (SINTEF 2017). External impacts to subsea systems (including wells) have not occurred within Santos and controls are in place which limit vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the subsea infrastructure is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of dry gas from a production well resulting in a *Minor (II)* consequence is considered to be Remote.	
Residual Risk	The residual risk associated with this event is **Very Low**

7.11.4.2 Subsea dry gas release from a gas production well or gas injector/producer as a result of loss of integrity from internal influences

Receptors	Threatened, migratory, and local fauna Physical environment and habitats

Consequence	II - Minor
The size of release from the gas subsea system is significantly smaller than the credible worst-case dry gas release from a gas well as a result of external impact, which has been assessed (**Section 7.11.4.1**). Given the size of the potential release of dry gas (77 MMscf over a 100 day period), the release is expected to cause only short term impact on local water quality and local marine fauna in the immediate site of release. The worst-case consequence is considered to be *Minor (II).*	
Likelihood	Occasional
In accordance with the Santos Risk Matrix, a worst-case subsea release of dry gas from gas production well or gas injector/producer with controls in place has been defined as a '*Occasional'* event as it 'has occurred before in Santos OR could occur within months to years'. Whilst Santos has experienced gas bubble releases from subsea equipment (gas lift jumpers) in the past, Santos has applied mitigation measures (i.e. design, inspection and maintenance, including replacement of equipment) which ensure that the integrity of the subsea infrastructure is restored and maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of dry gas from a gas flowline resulting in a *Minor (II)* consequence is considered to be *Occasional.*	
Residual Risk	The residual risk associated with this event is **Low**

7.11.4.3 Subsea release of dry gas from the gas subsea system (e.g. flowline or componentry such as a gas lift jumper) as a result of external impact

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor
The size of release from the gas subsea system is significantly smaller than the credible worst-case dry gas release from a gas well as a result of external impact, which has been assessed (**Section 7.11.4.1**). Given the size of the potential release of dry gas form the subsea system (84,790 scm) , the release is expected to cause only short term impact on local water quality and local marine fauna in the immediate site of release. The worst-case consequence is considered to be *Minor (B).*	
Likelihood	Remote
In accordance with the Santos Risk Matrix, a worst-case subsea release of dry gas from a production well has been defined as a 'Remote' event as it 'requires exceptional circumstances and is unlikely even in the long term. This likelihood is further supported by industry statistics between January 1980 through 31 December 2014, which show that a loss of well containment for production wells from an external events is 5.1% of all blowouts recorded within the area of study (Gulf of Mexico and North Sea) (SINTEF 2017). External impacts to subsea systems (including wells) have not occurred within Santos and controls are in place which limit vessels within a 500 m radius of the FPSO (500 m PSZ is in place around the DTM buoy). Santos have applied mitigation measures (i.e. design, inspection and maintenance) which ensure that the integrity of the subsea infrastructure is maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of dry gas from a production well resulting in a Minor (II) consequence is considered to be *Remote*.	
Residual Risk	The residual risk associated with this event is **Very Low**

7.11.4.4 Subsea dry gas release from the gas subsea system (e.g. a gas flowline) as a result of loss of integrity from internal influences

Receptors	Threatened, migratory, and local fauna Physical environment and habitats
Consequence	II - Minor
The size of release from the gas subsea system is significantly smaller than the credible worst-case dry gas release from a gas well as a result of external impact or internal influence), which has been assessed (**Section 7.11.4.1**). Given the size of the potential release of dry gas form the subsea system (468,336 kg/day maximum) , the release is expected to cause only short term impact on local water quality and local marine fauna in the immediate site of release. The worst-case consequence is considered to be *Minor (II).*	
Likelihood	Occasional
In accordance with the Santos Risk Matrix, a worst-case subsea release of dry gas from the gas subsea system (flowline or commentary) with controls in place has been defined as a 'Occasional' event as it 'has occurred before in Santos OR could occur within months to years'. Whilst Santos has experienced gas bubble releases from subsea equipment (gas lift jumpers) in the past, Santos has applied mitigation measures (i.e. design, inspection and maintenance, including replacement of equipment) which ensure that the integrity of the subsea infrastructure is restored and maintained. In accordance with the Santos Risk Matrix, given the control measures in place, the likelihood of a worst-case subsea release of dry gas from a gas flowline resulting in a *Minor (II)* consequence is considered to be *Occasional.*	
Residual Risk	The residual risk associated with this event is **Low**

7.11.5 Demonstration of ALARP

External impact controls

The location and depth (340-400 m) of the operational area reduces the likelihood of external vessels impacting the gas subsea system. The depth of water is too deep for vessel anchoring, including tankers. Drilling activities are not proposed under this EP and therefore any rig anchoring required in the Operational Area will be managed under a separate EP. While trawling could potentially be used by the North West Slope Trawl Fishery, the Operational Area has not been historically fished with effort restricted to east of the Montebello/ Barrow/ Lowendal Islands. Consultation with the fishing industry is included in **Section 4** of this EP.

Operational vessels undertaking subsea inspection activities are required to have dynamic positioning allowing subsea inspection activities to be performed without anchoring and eliminating the risk of anchor dragging impacting the subsea system. The use redundancy in the positioning system provides assurance that inspection activities will not damage subsea infrastructure through dragging objects (e.g. ROVs).

The key dropped object prevention controls preventing dropped objects onto subsea infrastructure is the provision of load alarms on FPSO cranes. Lifting procedures and inspection/testing requirements for cranes and lifting equipment on the FPSO and vessels reduces the risk of dropped objects onto the subsea production system. Transferring of equipment materials and waste between support vessels and the FPSO cannot be eliminated from the operational area and thus the risk of dropped objects cannot be removed.

The primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005). This system responds to both automatic and manual activation, with automatic activation triggered by abnormal process conditions, such as pressure drop across the subsea production system. The emergency shutdown system functionality and reliability is maintained through regular testing of the shutdown systems and the subsea valves. The regular testing and maintenance of the emergency shutdown and blowdown systems are managed through Performance Standard Assurance Plans (PSAPs), which provide the work instructions and performance criteria to test and service the shutdown and blowdown systems. The relevant PSAPs contain specific performance criteria as detailed below:

+ PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06). The performance criteria specified in PS-06 includes:
  - ESDV location, ESDV actuation requirements, Valve travel timings, acceptable leakage rates for riser ESDVs
+ PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) for the Well and Tree Valves except for the water injection wells. The performance criteria specified in PS-07 includes:
  - Master valve and wing valve testing and leak rate requirements, Master and Wing valve closure requirements, hydraulic system dump capabilities
+ PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). The performance criteria for Safety instrumented Systems in PS-08 includes:
  - The Safety Integrated system shall initiate shutdown and blowdown of the process during abnormal process conditions in accordance with the Cause and Effects Diagrams and alarm and trip schedule, ESD pushbutton locations, Reliability/availability achievements through redundancy, backup power, regular function testing and self-diagnostic capability.

The relevant PSAPs are listed as control measures with relevant performance standards in **Table 8-2**.

The maintenance and regular testing of the ESD and blowdown systems and the subsea valves managed through the PSAPs ensures a functional, available, reliable, survivable independent control ensuring the emergency shutdown and gas blowdown functionality, resulting in near-instantaneous shut in following loss of pressure and is considered to reduce the release volume to ALARP for a major leak/rupture scenario.

A functioning and tested ESD and blowdown system in accordance with the relevant PSAPs is designed retain liquid in on board and blowdown gas rather than discharge to environment in the event of an emergency situation. Other means of mitigating an emergency situation (such as over pressure) may be to discharge or release hydrocarbon to the marine environment. The NV ESD and blowdown system is therefore considered ALARP.

Function testing and inspection frequency and intervals within Santos PSAPs are based on a combination of:

+ Industry recommendations / standards
+ Manufacturers recommendations
+ Statutory obligations
+ Integrity risk (based on previous inspections or other triggers)

Unwarranted function testing and inspection greater than that of a PSAP approach provides little environmental benefit, as it does not significantly increase integrity assurance further. Costs have been determined to grossly outweigh environmental benefit.

A PSAP deviation process is detailed in the Santos Permitted Operations Procedure (QE-00-IG-00183), which provides allowance for deferral of PSAP assurance activities on a completion of a risk assessment process, which shows safe operations can continue and integrity can be maintained. Further details on this process is provided in **Section 8.3.1.1**.

<u>Internal influence controls</u>

As described above for external impact, the primary mechanism to immediately respond to a release of hydrocarbon from the subsea production system is via the emergency shutdown system managed through the Ningaloo Vision Incident Response Plan (TV-22-IF-00005) and PSAPs provide the work instructions and performance criteria to test and service the shutdown and blowdown systems.

The NOPSEMA approved WOMP includes control measures to prevent loss of well integrity and well control, including specified barriers.

The integrity of the gas subsea system is maintained through planned inspection, monitoring and testing of its components ensuring that the system operates within its design requirements and there is no unacceptable degradation of the system (e.g. materials, or ESD valve shutdown time/leakage etc.). Inspection of subsea infrastructure made in accordance with the Inspection Monitoring and Maintenance Plan (IMM Plan) and Santos PSAPs will ensure subsea infrastructure integrity is maintained.

IMMR includes an annual GVI of hydrocarbon containing subsea systems and structures. IMMR is in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007). which provides inspection frequencies, scope and acceptance criteria to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment. IMMR campaigns may also opportunistically identify small leaks during inspections, otherwise undetected through the NV control room or production data review, through the annual GVI. Hence, the annual GVI subsea leak inspection may be completed in a number of campaigns within the calendar year.

Frequencies for IMMR is based on a schedule set within Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007) (see **Table 2-9**) and includes nominal inspection frequencies and a commitment to an annual GVI inspection of hydrocarbon containing subsea systems and structures. The nominal IMMR frequencies and intervals may also be increased on the basis of risk (**Section 2.13.1**. Risk assessments are undertaken following physical events, integrity assessments or other triggers (e.g. inspections or analysis results). Based on these risk assessments additional GVI inspections may be performed. Conducting IMMR when not required presents unwarranted risks (e.g. risks associated with vessel use, marine growth removal) and additional costs which grossly outweigh the environmental benefit.

A number of controls in addition to the IMMR were investigated to detect small leaks:

+ Continuous use of the ROV for monitoring of leaks.
+ Realtime monitoring of the wells for small leaks using pressure and temperature instrumentation.

As detailed in **Table 7-35**, these controls either are ineffective or costs associated grossly outweigh the environmental benefits. As such, the use of IMMR to mitigate and small detect leaks, an annual frequency set for GVI of the hydrocarbon containing elements of the subsea production system, and the ability to increase frequency based on output of a risk assessment approach has been determined ALARP.

In the event of a small leak (below NV process control system detectable levels) from the subsea system (including flowlines and gas lift jumper), it is credible that the leak is undetected for a period until periodic inspection by ROV (e.g. A worst case scenario would be that a failure in integrity occurs immediately after one ROV survey and is not detected until the next survey). Continuous ROV monitoring of subsea system is not practical and costs associated with this grossly outweigh the benefit. In addition, having a ROV continually monitoring subsea presents additional environmental risks. The only way to realise a small leak is to through periodic inspections in accordance with the Van Gogh and Coniston-Novara Subsea IMM Plan (TV-35-RU-10007).

Burying the subsea infrastructure under the seabed and protecting the subsea infrastructure with mattresses was investigated as a mitigation against dropped objects and anchor drag impacts. However, the large cost associated, and additional seabed disturbance impacts were determined to be disproportionate compared to risk. Operational issues may also arise when inspection and maintenance is required.

The control measures adopted are based on best practice and accepted as suitable for the offshore oil and gas industry in reducing risk. Santos has where practicable, adopted all reasonable controls for reducing the risk.

With the above control measures in place, Santos deem that the risk from an unplanned subsea release of dry gas is ALARP.

7.11.6 Acceptability Evaluation

Is the risk ranked between Very Low to Medium?	Yes –Residual risk is ranked as Low
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available

Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Management consistent with OPGGS Regulations including Safety Case and WOMP. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: + Conservation values of the identified protection priorities (**Section 3.2)** including the Muiron Island Marine Management Area, Ningaloo Australian Marine Park.; and Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015) + Commonwealth Conservation Advice on *Aipysurus apraefrontalis* (short-nosed seasnake) (2011) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Calidris canutus* (red knot) (2016) + Recovery Plan for Threatened Albatrosses and Giant Petrels (DSEWPaC, 2011) + Australian Fairy Tern (DSEWPaC, 2011) + Approved Conservation Advice for *Calidris ferruginea* (curlew sandpiper) (2015) + Approved Conservation Advice for *Numenius madagascariensis* (eastern curlew) (2015) + Approved Conservation Advice for *Limosa lapponica baueri* (bar-tailed godwit western Alaskan) (2016) + Approved Conservation Advice for *Limosa lapponica menzbieri* (bar-tailed godwit northern Siberian) (2016) + Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island))
Are risks and impacts consistent with the Santos Environment Health and Safety Policy?	Yes – Aligns with the Santos Environment Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – No concerns raised
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP assessment above)

The risk of a subsea Van Gogh release (dry gas) from a well leak is Low . Additional industry standard control measures to reduce the chance of the event occurring (and minimise impacts) have also been implemented including (but not limited to) inspection monitoring and maintenance of subsea infrastructure, production operating procedures, NOPSEMA accepted WOMP, navigational and petroleum safety and cautionary zones and spill response (OPEP).

The control measures proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect of the NV Operations.

In accordance with Santos risk assessment process, the residual risk is considered to be Low and ALARP. The proposed control measures will reduce the risk of impacts from a subsea Van Gogh release (dry gas) from a well leak to a level that is considered acceptable.

8 Implementation Strategy

OPGGSR 2009 Requirements
Regulation 14(1)
The environment plan must contain an implementation strategy for the activity in accordance with this regulation.
Regulation 14(10)
The implementation strategy must comply with the Act, the regulations and any other environmental legislation applying to the activity.

The specific measures and arrangements that will be implemented in the event of an oil pollution emergency are detailed within the Ningaloo Vision Oil Pollution Emergency Plan (OPEP) (TV-00-RI-00003.02).

Stakeholder engagement is assessed separately for the requirements of the activities. Ongoing stakeholder management strategies are discussed in **Section 4.**

8.1 Environmental Management System

OPGGS(E)R 2009 Requirements
Regulation 14(3)
The implementation strategy must contain a description of the environmental management system for the activity, including specific measures to be used to ensure that, for the duration of the activity: (a) the environmental impacts and risks of the activity continue to be identified and reduced to a level that is as low as reasonably practicable; and (b) control measures detailed in the environment plan are effective in reducing the environmental impacts and risks of the activity to as low as reasonably practicable and an acceptable level; and (c) environmental performance outcomes and standards set out in the environment plan are being met.

The Santos Management System exists to support its ethical, professional and legal obligations to undertake work in a manner that does not cause harm to people or the environment. The Santos Management System is a framework of policies, standards, processes, procedures, tools and control measures that, when used together by a properly resourced and competent organisation, result in these outcomes:

+ A common HSE approach is followed across the organisation;
+ HSE is proactively managed and maintained;
+ The mandatory requirements of HSE management are implemented and are auditable;
+ HSE management performance is measured and corrective actions are taken;
+ Opportunities for improvement are recognised and implemented; and
+ Workforce commitments are understood and demonstrated.

This implementation strategy is designed to meet the requirements of the EP to require that:

+ Environmental impacts and risks continue to be identified for the duration of the activity and reduced to ALARP;
+ Control measures are effective in reducing environmental impacts and risks to ALARP and acceptable levels;
+ Environmental performance outcomes and standards set out in this EP are met; and
+ Stakeholder consultation is maintained throughout the activity as appropriate.

8.2 Environment Health and Safety Policy

The Santos Environment Health and Safety Policy (**Appendix A**) clearly sets out the strategic environmental outcomes and the commitment of the management team to continuous environmental performance improvement. This EP has been prepared in accordance with the fundamentals of this policy. By accepting employment with Santos, each employee and contractor is made aware during the recruitment process that he or she is responsible for the application of this policy.

8.3 Hazard Identification, Risk and Impact Assessment and Controls

Hazards and associated environmental risks and impacts for the proposed activities have been systematically identified and assessed in this EP (refer to **Sections 6** and **7**). The control measures and environmental performance standards that will be implemented to manage the identified risks and impacts, and the EPOs that will be achieved, are detailed below.

To ensure that environmental risks and impacts remain acceptable and ALARP during the activity and for the duration of this EP, hazards will continue to be identified, assessed and controlled as described in Document Management (**Section 8.12**) Audits and Inspections (**Section 8.13**).

Any new, or proposed amendment to a control measure or environmental performance standard or outcome will be managed in accordance with the Environment Management of Change Procedure (EA-91-IQ-10001) (**Section 8.12.2**).

Oil spill response control measures and environmental performance standards and outcomes are listed in the OPEP.

8.3.1 Performance Standard Assurance Plans

Where relevant, performance standard assurance plans (PSAPs) are referred to throughout this EP to provide evidence that critical systems are maintained in accordance with their design criteria. These plans, with titles beginning 'PS-', detail the performance criteria and associated maintenance routines, including frequency and schedule of inspections, and ensure compliance with relevant regulations (e.g., COLREGS) where appropriate.

PSAPs provide the link from the Safety Critical Element Performance Standards to the work instructions that perform the assurance activity, the interval that they are performed at, and lists all equipment that is associated with the performance standard

8.3.1.1 Permitted Operations Determination

Permitted operations determination is managed in accordance with the Santos Permitted Operations Procedure (QE-00-IG-00183). The permitted operations determination is in place to ensure safe operations, safety case and environment plan compliance in the following scenarios:

+ Deferral of Performance Standard assurance activities;
+ Deviations to Performance Standard SCE performance criteria, and;
+ Other scenarios such as a change in operating status which results in non-compliance with the relevant facility safety case or WOMP as required.
+ Deviation from a technical specification / standards that could results in additional demand or the impairment of a SCE.

In these scenarios, the deviation, deferral or non-compliance may increase the inherent risk above the level present during normal operations, and additional controls may be required to continue with safe NV operation. Therefore, central to the Permitted Operations Procedure (QE-00-IG-00183) is a risk assessment. A Permitted Operations Certificate is issued when it can be demonstrated that safe operations can continue.

Reviews of the status of deviations and deferrals, including the plans and achieved progress towards resolution occurs no more than once every two months. The frequency of review meetings may be increased at the discretion of the superintendent or Operations Manager.

Auditing of the permitted operations system is carried out every 48 months. The audit involves a review of a representative sample of permitted operations at various stages and focuses on compliance against the permitted operations.

8.4 Environmental Performance Outcomes

To ensure environmental risks and impacts will be of an acceptable level, environmental performance outcomes have been defined and are listed in **Table 8-1**. These outcomes will be achieved by implementing the identified control measures to the defined environmental performance standards.

Table 8-1: Environmental Performance Outcomes

Reference	Environmental Performance Outcomes
EPO-NV-01	No injury or mortality to EPBC Act 1999 and WA Biodiversity Conservation Act 2016 listed fauna during operational activities
EPO-NV-02	Reduce impacts to marine fauna from lighting on the FPSO and support vessels through limiting lighting to that required by safety and navigational lighting requirements.
EPO- NV-03	Reduce impacts to air and water quality from planned discharges and emissions from operational activities
EPO-NV-04	Seabed disturbance is limited to the operational area
EPO-NV-05	Reduce impacts on other marine users through the provision of information to relevant stakeholders such that they are able to plan for their activities and avoid unexpected interference
EPO-NV-06	Limit adverse impacts to values and ecological integrity of the Commonwealth marine area by ensuring a species protection level of PC99 (based on ANZG 2018) for water quality is achieved outside the PW mixing zone boundary* [EPO-NV-06]. (* PW mixing zone determined to be 459 m from the FPSO during a ≤30 mg/l PW discharge and 2,182 m from the FPSO during a ≤70 mg/l PW discharge)
EPO-NV-07	Limit adverse impacts to values and ecological integrity of the Commonwealth marine area by ensuring ANZG 2018 sediment quality guideline values are not exceeded outside the 30 mg/l PW mixing zone boundary
EPO-NV-08	No introduction of marine pest species
EPO-NV-09	No unplanned objects, emissions or discharges to sea or air
EPO-NV-10	No loss of containment of hydrocarbons to the marine environment

8.4.1 Control Measures and Performance Standards

The control measures that will be used to manage identified environmental impacts and risks, and the associated statements of performance required of the control measure (i.e. environmental performance standards) are listed in **Table 8-2**. Measurement criteria outlining how compliance with the control measure and the expected environmental performance could be evidenced are also listed.

Performance Standards and associated measurement criteria relating to contingency oil response operations are contained within the NV Operations OPEP (TV-00-RI-00003.02).

Table 8-2: Control Measures and Environmental Performance Standards

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Procedure for interacting with marine fauna	NV-CM-01	Vessels comply with Santos Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003) which ensures compliance with Part 8 of the EPBC Regulations 2000 which includes controls for minimising the risk of collision with marine fauna.	NV-CM-01-EPS-01	Completed vessel statement of conformance demonstrates compliance to relevant sections of Santos Protected Marine Fauna Interaction and Sighting Procedure	EPO-NV-01	6.1 6.8 7.2
		Helicopters contractor procedures comply with Santos Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003) which ensures compliance with Part 8 EPBC Regulations 2000 which includes controls for minimising interaction with marine fauna.	NV-CM-01-EPS-02	Helicopter contractor procedures align with relevant sections of Santos Protected Marine Fauna Interaction and Sighting Procedure	EPO-NV-01	6.1 6.8 7.2
		UAV's comply with Santos Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003) which ensures compliance with the Biodiversity Conservation Regulations 2018 which includes controls for minimising the risk of interaction with marine fauna.	NV-CM-01-EPS-03	Contractor procedures align with relevant sections of Santos Protected Marine Fauna Interaction and Sighting Procedure	EPO-NV-01	6.1 7.2

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Lighting will be used only as required for safe work conditions and navigational purposes	NV-CM-02	Where an IMMR activity may require 24-hour lighting, a project execution plan, planning and inductions, will include a requirement to minimise external lighting where practicable during the activity.	NV-CM-02-EPS-01	Where an IMMR activity may require 24-hour lighting, a project execution plan, planning and inductions, will include a requirement to minimise external lighting where practicable during the activity.	EPO-NV-02	6.2
Premobilisation review and planning of lighting on vessels is undertaken prior to IMMR activities commencing	NV-CM-03				EPO-NV-02	6.2
FPSO Planned Maintenance System and class certification system	NV-CM-04	Documented maintenance program is in place for equipment on the FPSO that provides a status on the maintenance of equipment.	NV-CM-04-EPS-01	CMMS records show maintenance of equipment on the FPSO occurs	EPO-NV-03 EPO-NV-06 EPO-NV-07	6.3 6.7
		FPSO class certification for equipment relating to boiler and Inert gas system is in place	NV-CM-04-EPS-02	Current FPSO certification of class	EPO-NV-03	6.3
		Ensure offtake equipment (including the offtake floating hose) is maintained to reduce likelihood of loss of offtake integrity events during crude transfers / offtakes, through the following routine checks:	NV-CM-04-EPS-03	CMMS records show maintenance of offtake equipment on the FPSO occurs	EPO-NV-03	7.8

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Visual inspections + String hydrotest				
Vessels Planned Maintenance System	NV-CM-05	Documented maintenance program is in place for equipment on vessels that provides a status on the maintenance of equipment.	NV-CM-05-EPS-01	Vessel PMS records show equipment on vessels is maintained	EPO-NV-03 EPO-NV-09 EPO-NV-10	6.3 6.8 7.3 7.4 7.7
Fuel oil quality	NV-CM-06	MARPOL-compliant (Marine Order 97) fuel oil will be used by vessels and the FPSO during the activities.	NV-CM-06-EPS-01	Fuel supply specifications show fuel is MARPOL-compliant on vessels and FPSO	EPO-NV-03	6.3 6.8
Air Pollution Prevention Certificate (IAPP)	NV-CM-07	Pursuant to Marine Order 97 (vessels) and MARPOL Annex VI (FPSO) will maintain a current International Air Pollution Prevention (IAPP) Certificate which certifies that measures to prevent ozone-depleting substance (ODS) emissions, and reduce Nox, Sox and incineration emissions during the activity are in place.	NV-CM-07-EPS-01	Current IAPP certificate is in place for vessels and FPSO	EPO-NV-03	6.3 6.8
Ozone depleting substance handling procedures	NV-CM-08	Ozone-depleting substances (ODS) on vessels and FPSO is managed in accordance with Marine Order 97 (vessels) and MARPOL Annex VI (FPSO) to reduce the risk of an accidental release of ODS to air.	NV-CM-08-EPS-01	Completed ODS Record Book or recording system is on vessel in accordance with Marine Order 97 (vessels) and MARPOL VI (FPSO)	EPO-NV-03	6.3 6.8

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Vessel waste incineration management	NV-CM-09	Waste incineration on vessels is managed in accordance with Marine Order 97.	NV-CM-09-EPS-01	Completed vessel waste record book or recording system in accordance with Marine Order 97	EPO-NV-03	6.3
Power generation system fuel	NV-CM-10	FPSO power generation systems reduce CO_2 emissions to atmosphere by primarily using produced fuel gas.	NV-CM-10-EPS-01	Fuel gas usage and diesel consumption records show FPSO power generation is primarily using produced fuel gas	EPO-NV-03	6.3
National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015	NV-CM-11	National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 has been used to measure, report and manage the relevant NV Operations emissions and they are compliant with the requirements set by the Clean Energy Regulator	NV-CM-11-EPS-01	Records show that National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 has been used to measure, report and manage the relevant NV Operations emissions and they are compliant with the requirements set by the Clean Energy Regulator	EPO-NV-03	6.3
Emissions Reporting required by the Clean Energy Regulator through the National Greenhouse and Energy Reporting (NGERS)	NV-CM-12	NGERS reporting is lodged as per the Clean Energy Regulator submission requirements	NV-CM-12-EPS-01	Records show that NGERs reports have been lodged as per Clean Energy Regulator submission requirements	EPO-NV-03	6.3

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
National Pollution Inventory (NPI) Reporting	NV-CM-13	NPI reporting is lodged as per the NPI submission requirements	NV-CM-13-EPS-01	Records show that NPI reports have been lodged as per NPI submission requirements	EPO-NV-03	6.3
Dropped object prevention controls	NV-CM-14	Crane operations comply with relevant aspects of Crane operations procedure (NV-91-IG-10013), which require: + Cranes are inspected by an authorized Third-Party Inspector + Routine crane maintenance is out in accordance with the manufacturer's specifications + Lifting over pipe work or process equipment is only approved by the OIM after a risk assessment is undertaken	NV-CM-14-EPS-01	CMMS records show cranes are maintained and inspected Training records show crane operator is competent in accordance with Crane operations procedure (NV-91-IG-10013) Risk assessment documentation for lifting over pipe work or process equipment or non-routine lifts	EPO-NV-04 EPO-NV-09 EPO-NV-10	6.4 7.3 7.4 7.7 7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Non-routine lifts are only undertaken after a risk assessment is undertaken and a lifting plan is developed + A pre-start check is completed which includes visual inspection of the entire crane to ensure that there is nothing obstructing the operation of the crane + All cranes shall be operated by competent crane driver (or during training is supervised by a competent operator)		Completed crane pre-start checklist		
		FPSO lifting operations comply the Lifting operations procedure (QE-91-IF-00017) which specifies the minimum standards to be implemented and includes requirements on: + Roles and responsibilities + Lift planning + Engineered lifts + Permits and risk assessments	NV-CM-14-EPS-02	CMMS records and Lifting Equipment Register shows lifting equipment is certified.	EPO-NV-04 EPO-NV-09 EPO-NV-10	6.4 7.3 7.4 7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Operational procedural guidelines lifting equipment (inspection and certification) + Lift communications + Training and competency				
		A vessel undertaking lifting activities that needs a Safety Case will have the following requirements in place to manage lifts and avoid dropped objects: + Activity specific lifting operation plan; + A SMS bridging document to the NV Safety Case; and + SIMOPs to manage interface with NV Operations which includes permit to work interfaces, heavy lift exclusion zones and matrix of permitted operations (MOPO).	NV-CM-14-EPS-03	Activity specific lifting operation plan is in place SMS bridging document is in place SIMOPs is in place	EPO-NV-04 EPO-NV-09 EPO-NV-10	6.4 7.3 7.4 7.7 7.7
		A vessel undertaking lifting activities that don't require a Safety Case will have an activity specific procedure in place to manage lifts and avoid dropped objects.	NV-CM-14-EPS-05	Activity specific procedure includes management of lifts and avoidance of dropped objects	EPO-NV-04 EPO-NV-09 EPO-NV-10	6.4 7.3 7.4 7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Dropped object recovery	NV-CM-15	Objects dropped overboard are recovered to mitigate the environmental consequences from objects remaining in the marine environment, unless the environmental consequences are negligible, or safety risks are disproportionate to the environmental consequences.	NV-CM-15-EPS-01	Fate of dropped objects detailed in incident documents.	EPO-NV-04 EPO-NV-09	6.4 7.3 7.4
Petroleum safety zone and cautionary area	NV-CM-16	A 500 m PSZ defined around the DTM buoy and marked on Australian Hydrographic Service nautical charts	NV-CM-16-EPS-01	AHS Nautical Chart shows 500 m PSZ around the DTM buoy.	EPO-NV-05 EPO-NV-10	6.5 7.6 7.7 7.7 7.9 7.10 7.11
		A 2.5 nm cautionary zone is in place around the subsea infrastructure	NV-CM-16-EPS-02	AHS Nautical Chart show cautionary zone around the subsea infrastructure.	EPO-NV-05 EPO-NV-10	6.5 7.6 7.7 7.7 7.9 7.10 7.11
Navigational charting of infrastructure	NV-CM-17	Subsea infrastructure is charted on AHS Nautical Charts	NV-CM-17-EPS-01	AHS Nautical Chart show subsea infrastructure	EPO-NV-05 EPO-NV-10	6.5 7.6 7.7 7.11

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Navigation lighting and aids	NV-CM-18	Navigational lighting and communication aids on the FPSO is provided, maintained and inspected at frequencies outlined within PS-04 Navigational Aids (NV- 00-RG-10053.04) which manages the methods to alert marine vessels and aircraft of the position of the FPSO to minimise the potential for collision.	NV-CM-18-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-05 EPO-NV-10	6.5 7.7 7.9 7.10
		Navigation equipment is compliant with SOLAS (FPSO and offtake tanker) and AMSA Marine Orders Part 30: Prevention of Collisions, and with Marine Orders Part 21: Safety of Navigation and Emergency Procedures (vessels)	NV-CM-18-EPS-02	Inspection records show FPSO navigation equipment is compliant with SOLAS	EPO-NV-05 EPO-NV-10	6.5 7.7 7.9 7.10
				Completed vessel statement of conformance demonstrates vessel is compliant with AMSA Marine Orders Part 30 and 21		
				Offtake Tanker's acceptance to comply		
Seafarer Certification	NV-CM-19	Vessel marine crew are trained and competent, in accordance with Marine Order 70, to navigate vessels and reduce interaction with other marine users.	NV-CM-19-EPS-01	Training records can be made available to show vessel marine crew are trained and competent, in accordance with Marine Order 70	EPO-NV-05 EPO-NV-10	6.5 7.7 7.9 7.10
	NV-CM-20	Santos provided a quarterly consultation update to relevant	NV-CM-20-EPS-01	Records of transmittal.	EPO-NV-05	6.5

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Stakeholder consultation		stakeholders, and all stakeholder correspondence has been recorded in stakeholder database.		Stakeholder communications database.		
		All correspondence with external stakeholders is recorded.	NV-CM-20-EPS-02	Saved consultation records	EPO-NV-05	6.5
Notification to AHO and JRCC prior to commencement of vessel based IMMR activities	NV-CM-21	Notification is made to AHO and JRCC prior to commencement of vessel based IMMR activities	NV-CM-21-EPS-01	Records of transmittal	EPO-NV-05	6.5
DTM pick up line arrangement attachment management, when the FPSO is off station for - longer term absences such as shipyard campaigns, or - if the FPSO is permanently off station	NV-CM-22	When the FPSO is off station for longer term absences (e.g. Shipyard campaign), the DTM pick up line arrangement length is shortened, to reduce the risk of interference with other vessels and reduce the potential for entanglement with marine fauna.	NV-CM-22-EPS-01	Records show that the pickup line arrangement has been shortened when the FPSO is off location for longer term absences such as shipyard.	EPO-NV-05	6.5 7.2
		When the FPSO is permanently off station the DTM pick up line arrangement length is shortened to prevent streaming of the line on the surface.	NV-CM-22-EPS-02	Records show that the pickup line has been reduced to prevent streaming of the line on the surface.	EPO-NV-05	6.5 7.2
Add a float/buoy to the DTM pick-up line arrangement when FPSO off station for longer term absences	NV-CM-23	A float/buoy is placed on the end of the DTM Pick up line arrangement when the FPSO is off station for longer term absences (e.g. Shipyard campaign), to reduce the potential for the DTM pick up line to	NV-CM-23-EPS-01	Records show that the float/buoy was added to the DTM pick up line arrangement.	EPO-NV-05	6.5

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
(e.g. shipyard campaigns).		become entangled on itself creating a birdsnest like structure.				
Sewage system	NV-CM-24	Pursuant to Marine Order 96 (vessels) and MARPOL Annex IV (FPSO) vessels and FPSO have a current International Sewage Pollution Prevention (ISPP) Certificate, which certifies that required measures to reduce impacts from sewage disposal are in place	NV-CM-24-EPS-01	Current ISPP certificate	EPO-NV-03	6.6 6.8
		Documented maintenance program is in place on the FPSO and vessels that provides a status on the maintenance of equipment	NV-CM-24-EPS-02	Vessel maintenance records indicate status	EPO-NV-03	6.6 6.8
				CMMS FPSO records indicate status		
		Sewage from vessels and FPSO is discharged, in accordance with Marine Order 96 (vessels) and MARPOL Annex IV (FPSO).	NV-CM-24-EPS-03	Records demonstrates that sewage was appropriately discharged or retained	EPO-NV-03	6.6 6.8
				CMMS FPSO records indicate status		
Oily mixture system	NV-CM-25	Oily mixtures only discharged from to sea in accordance with Marine Order 91 (vessels) and MARPOL Annex I (FPSO)	NV-CM-25-EPS-01	Oil record book is in place	EPO-NV-03	6.6 6.8
		Documented maintenance program is in place on the FPSO and vessels that provides a status on the maintenance of equipment	NV-CM-25-EPS-02	Vessel maintenance records indicate status		

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
				CMMS FPSO records indicate status		
		Pursuant to Marine Order 91(vessel (> 400t) and MARPOL Annex I (FPSO), vessel and FPSO will have an International Oil Pollution Prevention (IOPP) Certificate which certifies that required measures to reduce impacts of planned oil discharges are in place	NV-CM-25-EPS-03	Current IOPP certificate in place for vessel and FPSO		
FPSO deck drain system and bunding	NV-CM-26	Preventative maintenance on FPSO bunding and associated equipment is completed in accordance certificate of class.	NV-CM-26-EPS-01	Certificate of class	EPO-NV-03 EPO-NV-09	6.6 6.8 7.4
Garbage management	NV-CM-27	Garbage management plan is implemented on vessels and FPSO to reduce the risk of waste released to sea in accordance with Marine Order 95 (vessel) and MARPOL Annex V (FPSO) The plan includes detail for: + Bin types; + Lids and covers; + Waste segregation; + Bin storage; and + Food waste.	NV-CM-27-EPS-01	Garbage record book in place on vessel and FPSO Audit and inspection records show waste is managed in accordance with Marine Order 95 (vessel) and MARPOL Annex V (FPSO)	EPO-NV-03 EPO-NV-09	6.6 6.8 7.3

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		Pursuant to Marine Order 95 (vessels) and MARPOL Annex V (FPSO), placards displayed notify personnel of waste disposal restrictions.	NV-CM-27-EPS-02	Audit and inspection records show placards are displayed	EPO-NV-03 EPO-NV-09	6.6 6.8 7.3
Deck cleaning product selection	NV-CM-28	Deck cleaning products planned to be released to sea from the vessels and FPSO meet the criteria for not being harmful to the marine environment according to MARPOL Annex II.	NV-CM-28-EPS-01	Safety Data Sheet (SDS) and product supplier supplementary data as required shows compliance to criteria for not being harmful	EPO-NV-03	6.6
Chemical Selection Procedure	NV-CM-29	Production or process chemicals potentially discharged to sea are CHARM Gold/Silver or non-CHARM D/ E rated through OCNS, or PLONOR substances listed by OSPAR, or have a completed risk assessment as per Santos Operations Chemical Selection, Evaluation and Approval Procedure (EA-91-II-10001) so that only environmentally acceptable products are used. The selection criteria for chemical preference through the risk assessment process as outlined Santos Operations Chemical Selection, Evaluation and Approval Procedure (EA-91-II-10001) is low aquatic toxicity (e.g. EC50/LC50 > 100 mg/L), low bioaccumulation	NV-CM-29-EPS-01	Completed Santos risk assessments show chemicals selected are acceptable as per Santos Operations Chemical Selection, Evaluation and Approval Procedure (EA-91-II-10001)	EPO-NV-03 EPO-NV-06 EPO-NV-07	6.6 6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		potential (e.g. Log Pow <3) and readily biodegradable (e.g. >60 in 28 days OECD 306).				
PW Adaptive Management Plan (**Appendix H**)	NV-CM-30	During loss of the OIW inline analyser signal, the frequency of onboard manual spectrophotometer measurements for OIW concentration is increased to every 3 hours.	NV-CM-30-EPS-01	PW monitoring records show that on loss of OIW inline analyser, the frequency of onboard spectrophotometer measures of OIW concentration increased to every 3 hours	EPO-NV-06 EPO-NV-07	
		Should trends in OIW concentration between the OIW analyser and the onboard spectrophotometer show readings trending away from each other during a permanent discharge scenario the OIW analyser the following tiered response occurs: 1. Clean the analyser. If OIW analyser still deviates: 2. Calibrate the analyser in accordance with manufacturers recommendations. PW will only be discharged to the marine environment achieving ≤30 mg/L 24 hour rolling average.	NV-CM-30-EPS-02	Records show that when trends in OIW concentration between the OIW analyser and the onboard spectrophotometer show readings trending away from each other the following tiered response occurs: 1.Clean the analyser. If OIW analyser still deviates: 2.Calibrate the analyser in accordance with manufacturers recommendations. OIW monitoring and PW discharge demonstrate that PW was only	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
				discharged to the marine environment achieving ≤30 mg/L 24 hour rolling average.		
		Should the NATA accredited laboratory OIW concentration exceed the manual spectrophotometer laboratory results the OIW analyser and the spectrophotometer is re-calibrated in accordance with manufacturers recommendations.	NV-CM-30-EPS-03	Calibration records show that the spectrophotometer has be re-calibrated in accordance with manufacturers recommendations when the NATA lab OIW concentration exceeds the manual spectrophotometer laboratory.	EPO-NV-06 EPO-NV-07	6.7
		PW flow rate is tracked on 3-hourly production averages. If flow rate trending towards exceeding 23,040 $m^{3/}$day, production is managed so as not to exceed the allowable flow rate.	NV-CM-30-EPS-04	PW flowrate records show that the flow rate has not exceed 23,040m^3/day and when flow rate is trending towards exceeding 23,040m^3/day, production is managed so as not to exceed the allowable flow rate.	EPO-NV-06 EPO-NV-07	6.7
		If concentrations of potential contaminants in PW are greater than ANZECC/ARMCANZ(2000) / ANZG (2018) guideline values or most recent chemical characterisation Or	NV-CM-30-EPS-05	Records show that the MOC process (as per Section 8.11.2 of the EP) and PW risk assessment (Section 1.2 of Appendix H) was followed and that if the assessment showed that the PW is not ALARP	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		If chemical characterisation indicates that PW mixing zone to meet ANZECC/ARMCANZ(2000) / ANZG (2018) 99% species protection has not been met. The following is undertaken: 1. If PW is being discharged, then an MOC (as per Section 8.11.2 of the EP) addressing the factors described in the PW risk assessment (Section 1.2 Appendix H) is completed. 2. Should the assessment show that the PW (if discharged) is not ALARP or acceptable, or is a significant increase in risk, then PW is directed inboard until corrective actions to the system are made, which assure the PW discharge is ALARP and acceptable.		or acceptable, or is a significant increase in risk, then PW was directed inboard until corrective actions to the system are made.		
OIW content for PW discharge to the marine environment is limited	NV-CM-31	PW discharged to the marine environment is at a OIW concentration of ≤30 mg/L over a rolling 24 hour average.	NV-CM-31-EPS-01	OIW concentration monitoring records show PW discharged of to the marine environment are ≤30 mg/L over a rolling 24 hour average	EPO-NV-06 EPO-NV-07	6.7
		During a High OIW discharge scenario as outlined in Section 6.7.1 and Table 6-19 of the EP, PW discharged to the marine	NV-CM-31-EPS-02	PW discharge and monitoring records show OIW concentrations in PW discharged of to the	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		environment is ≤70 mg/L over a rolling 24 hour average, and the discharge event does not occur for more than 7 days.		marine environment are less than 70 mg/L over a rolling 24 hour average, and the discharge occurred for no more than 7 days		
Inline OIW analyser to continuously monitor the OIW content concentrations	NV-CM-32	Inline OIW analyser is continuously monitoring (unless there is a loss of the OIW inline analyser signal, then Adaptive Management Plan is applied) the OIW content concentrations during PW discharge to the marine environment	NV-CM-32-EPS-01	Monitoring records confirm OIW is continuously monitored during PW discharges (unless there is a loss of the OIW analyser signal, then Adaptive Management Plan is applied)	EPO-NV-06 EPO-NV-07	6.7
Inline analyser OIW calibration and maintenance	NV-CM-33	Calibration of the inline OIW analyser in accordance with manufacturers recommendations is undertaken four times a year (approximately every 3 months).	NV-CM-33-EPS-01	Calibration records demonstrate that the OIW analyser has been calibrated approximately every 3 months	EPO-NV-06 EPO-NV-07	6.7
		OIW analyser Original Equipment Manufacturer (OEM) vendor undertakes a maintenance service of the analyser every 2 years.	NV-CM-33-EPS-02	OIW analyser maintenance records demonstrate analyser is fit for service	EPO-NV-06 EPO-NV-07	6.7
Manual laboratory spectrophotometer sampling of PW OIW content concentrations	NV-CM-34	During permanent and temporary discharge, on board manual laboratory sampling of PW is undertaken approximately every 6 hours using a spectrometer to verify readings from the inline OIW analyser and that OIW is ≤30 mg/L (rolling 24 hour average).	NV-CM-34-EPS-01	Sampling records confirm laboratory sampling of PW OIW has been undertaken every 6 hours during permanent and temporary discharge	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
NATA Laboratory sampling for chemical characterisation	NV-CM-35	During temporary and permanent discharge, a PW sample is taken for NATA laboratory chemical characterisation within 30 days of discharging and then every 3 months whilst discharging.	NV-CM-35-EPS-01	Chemical characterisation records confirm a sample has been taken for NATA laboratory chemical characterisation within 30 days of discharging and then every 3 months whilst discharging	EPO-NV-06 EPO-NV-07	6.7
		During reinjection a PW sample is taken for NATA laboratory chemical characterisation every 6 months whilst re-injecting	NV-CM-35-EPS-02	PW sampling records show sampling has been taken for NATA laboratory chemical characterisation every 6 months whilst re-injecting	EPO-NV-06 EPO-NV-07	6.7
		During a temporary discharge, an assessment (see **Section 1.2.1 of** Appendix H) is undertaken to assess if end of pipe PW sampling for chemical characterisation is required. If required, parameters are monitored so a Dilution Factor can be assessed and the extent of the PW mixing zone can be verified.	NV-CM-35-EPS-03	Documented decision of end of pipe PW sampling requirement and application of water quality chemical characterisation and assessment of extent of the PW mixing zone	EPO-NV-06 EPO-NV-07	6.7
Laboratory sampling for ecotoxicity in	NV-CM-36	During temporary discharge to the marine environment an assessment is undertaken to asses	NV-CM-36-EPS-01	Risk assessment has been completed on temporary discharges	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
accordance with ANZECC/ ARMCANZ 2000.		if an ecotoxicity test on the PW is required. Factors considered include time since last ecotoxicity test, nature and scale of discharge, operational changes since previous PW chemical characterisation results.		If assessment shows an increase in risk, PW ecotoxicity records show a sample for ecotoxicity testing has been taken within 3 months of discharge.		
		For permanent discharge to the marine environment when there are no ecotoxicity results within the last 6 months, then a sample for ecotoxicity testing is taken within 3 months of discharge and every 6 months thereafter.	NV-CM-36-EPS-02	PW ecotoxicity records show when there is no ecotoxicity results within the last 6 months, then a sample for ecotoxicity testing has been taken within 3 months of discharge to the marine environment and every 6 months thereafter.	EPO-NV-06 EPO-NV-07	6.7
		When laboratory sampling for ecotoxicity indicate an increase in safe dilution factors in comparison to those used to define the current PW mixing zone (Section 6.7), an MOC (as per Section 8.11.2) addressing the factors described in the PW risk assessment (Section 1.2 of Appendix H) is used to inform actions required to maintain compliance with PW Performance Outcome and Performance Standards	NV-CM-36-EPS-03	MOC records show that on an increase of safe-dilution factors an MOC has been completed and required actions were implemented to maintain compliance with the PW Performance Outcome and Performance Standards	EPO-NV-06 EPO-NV-07	6.7
Onboard laboratory	NV-CM-37	Calibration of the onboard laboratory spectrophotometer is in	NV-CM-37-EPS-01	Spectrophotometer calibration records	EPO-NV-06	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
spectrophotometer calibration		accordance with manufacturers recommendations and is undertaken bi-annually (i.e. twice a year).		demonstrate calibration has been undertaken bi-annually (i.e. twice a year)	EPO-NV-07	
		Calibration of the onboard laboratory spectrophotometer is in accordance with Preparation of the OIW Standards and Calibration of the Hach (TV-22-IG-00041.14).	NV-CM-37-EPS-02	Spectrophotometer calibration records demonstrate calibration has been undertaken in accordance with TV-22-IG-00041.14	EPO-NV-06 EPO-NV-07	6.7
Onboard laboratory chemical sampling	NV-CM-38	Onboard chemical sampling is undertaken in accordance the Oil in Produced Water Test (TV-22-IG-00041.05) which provides the requirements for onboard laboratory sampling including: + Responsibilities; + Equipment; + Sampling frequencies; + OIW specifications; + Testing method; and + Clean up and disposal of wastes	NV-CM-38-EPS-01	Records demonstrate sampling has been undertaken in accordance with TV-22-IG-00041.05	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Water quality field sampling	NV-CM-39	For temporary discharges to the marine environment the decision tree (Section 1.2.1 of Appendix H) is followed to asses water quality sampling requirements. Water quality field sampling (in accordance with Appendix I) occurs when the output shows its requirement.	NV-CM-39-EPS-01	Documented decision which follows the decision tree (Section 1.2.1 of Appendix H) has been completed. water quality field sampling (in accordance with Appendix I) is undertaken as required based on decision output.	EPO-NV-06 EPO-NV-07	6.7
		For permanent discharge to the marine environment water quality field sampling is undertaken within 6 months of discharge and then every 12 months thereafter.	NV-CM-39-EPS-02	Water quality field sampling records that water quality sampling has been undertaken within 6 months of discharge to the marine environment and then every 12 months thereafter	EPO-NV-06 EPO-NV-07	
		Should water field quality sampling indicate an exceedance of the ANZG (2018) 99% species protection outside the PW mixing zone, an MOC (as per Section 8.11.2) addressing the factors described in the PW risk assessment (Section 1.2 of Appendix H) is used to inform actions required to maintain compliance with the PW EPO and EPS.	NV-CM-39-EPS-03	Records show that on exceedance of 99% species protection outside the PW mixing zone, an MOC is completed and required actions are being implemented to maintain compliance with the PW EPO and EPS.	EPO-NV-06 EPO-NV-07	

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		Actions are implemented to maintain compliance with the PW EPO and EPS.				
		Water quality field sampling and analysis is undertaken in accordance with the protocols set within **Appendix I.**	NV-CM-39-EPS-04	Water quality field sampling records and analysis show that the protocols set in **Appendix I** have been followed	EPO-NV-06 EPO-NV-07	
		A dye test (or equivalent) with a PW stream discharge, is undertaken within 6 months of permanent PW discharge, in a manner that represents a volume and rate based on the reservoir characteristics and facilities expected water production rates at the time of the testing.	NV-CM-39-EPS-05	Records show that a dye test was undertaken within 6 months of permanent PW discharge	EPO-NV-06 EPO-NV-07	
Sediment and infauna sampling quality sampling	NV-CM-40	Sediment baseline quality sampling is undertaken within 12 months of EP acceptance prior to PW discharge, to provide baseline data on the seabed in Accordance with Appendix I.	NV-CM-40-EPS-01	Sediment sampling records show sediment quality sampling has been undertaken within 12 months of EP acceptance	EPO-NV-06 EPO-NV-07	6.7
		For temporary discharge to the marine environment sediment quality sampling is undertaken when the equivalent of 12 months full discharge over life of EP has occurred, or once before expiry of the EP, whichever is sooner.	NV-CM-40-EPS-02	Sediment sampling records show for temporary discharge to the marine environment sediment quality sampling is undertaken when the equivalent of 12 months full discharge over life of EP has occurred or once	EPO-NV-06 EPO-NV-07	

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
				before expiry of EP, whichever is sooner		
		For permanent discharge to the marine environment sediment quality sampling and infauna monitoring is undertaken at 5 yearly intervals (e.g. once within the life of the EP) in Accordance with **Appendix I**.	NV-CM-40-EPS-03	Sediment sampling records show for permanent discharge to the marine environment sediment quality sampling and infauna monitoring is undertaken at 5 yearly intervals (e.g. once within the life of the EP	EPO-NV-06 EPO-NV-07	
		Should sediment quality sampling indicate an exceedance of the ANZG (2018) 99% species protection within or outside the PW mixing zone, an MOC (as per Section 8.11.2) addressing the factors described in the PW risk assessment (Section 1.2 of Appendix H) is used to inform actions required to maintain compliance with PW Performance Outcome and Performance Standards.	NV-CM-40-EPS-04	MOC records show that on exceedance of 99% species protection within or outside the PW mixing zone, an MOC is completed and required actions are being implemented to maintain compliance with the PW Performance Outcome and Performance Standards	EPO-NV-06 EPO-NV-07	
		Sediment quality sampling and analysis is undertaken in accordance with the protocols set within **Appendix I.**	NV-CM-40-EPS-05	Records of sampling and analysis and scope show that the protocols set in **Appendix I** have been followed	EPO-NV-06 EPO-NV-07	
Critical spare PW re-injection pump availability	NV-CM-41	A critical spare PW re-injection pump is stocked and available for	NV-CM-41-EPS-01	Records show that a critical spare PW re-	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		use should existing PW re-injection pump fail.		injection pump is stocked and available		
Plan to only shutdown one PW pump, leaving two remaining pumps to continue to reinject PW during planned PW pump maintenance	NV-CM-42	During PW re-injection pump routine maintenance only one pump is planned to be shut-down at a time, leaving two remaining pumps to continue reinject PW.	NV-CM-42-EPS-01	Maintenance plans and records show that only one PW re-injection pump has been planned to be shut down, leaving two to reinject PW	EPO-NV-06 EPO-NV-07	6.7
PW treatment system	NV-CM-43	The PW system (water injection and topsides produced water treatment) is inspected, tested, and maintained in accordance with: + PS-03 Hydrocarbon Containment; Risers and Pipelines (NV-00-RG-10053.03) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). + PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08 Which aims to maintain integrity of the system. The above PSAPs provide details on: + Performance criteria	NV-CM-43-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions				
PW re-injection	NV-CM-44	PW is re-injected (i.e. not discharged overboard) 100 percent, up to 23,040 m^3 per day, unless operating under events under Scenario 2, 3, 4 or 5, as described in Tables 6-18 to 6-21.	NV-CM-44-EPS-01	A combination of production records including: + PW overboard flow meter records + Valve status records + Daily production and reinjection reporting Decision log is completed as per Figure 6-2 to Figure 6-5 for PW discharge scenarios.	EPO-NV-06 EPO-NV-07	6.7
Slops tank is managed and utilised for PW discharge when operationally feasible	NV-CM-45	PW is diverted to the slops tanks when the PW re-injection system is unavailable and it is operationally feasible to do so (e.g. slops has capacity).	NV-CM-45-EPS-01	Records (including CMMS records - Critical function testing of the pressure measuring instrumentation, alarm and trip schedule) show that PW has been diverted to the slops tanks on occasions when the PW re-injection system unavailable and it is operationally feasible to	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
				do so (e.g. slops has capacity)		
PW flowline operating within design pressures limits	NV-CM-46	PW flowline operates within design pressures to reduce integrity issues and PW system failures, which could lead to PW discharge to the marine environment.	NV-CM-46-EPS-01	Pressure records of the PW flowline show it is operating within design pressure limits	EPO-NV-06 EPO-NV-07	6.7
		A high flowline pressure alarm is in place which triggers a PW reinjection system shutdown should flowline pressures approach design pressures.	NV-CM-46-EPS-02	Records (including CMMS records - Critical function testing of the pressure measuring instrumentation, alarm and trip schedule) show that an alarm is in place which triggers a PW reinjection system shutdown should flowline pressures exceed design pressures.	EPO-NV-06 EPO-NV-07	
		A low flowline pressure trip is in place which triggers a PW reinjection system shutdown should flowline pressures drop below set pressure.	NV-CM-46-EPS-03	Records (including CMMS records - Critical function testing of the pressure measuring instrumentation, alarm and trip schedule) show that a pressure trip is in place which triggers a PW reinjection system shutdown and evidence is available on the shutdown should flowline pressures drop below set pressure.	EPO-NV-06 EPO-NV-07	

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Van Gogh Operating Procedure Subsea System Start-up (Depressurisation) (TV-35-IG-00195)	NV-CM-47	Start-up process of the subsea system has been managed in accordance with Van Gogh Operating Procedure Subsea System Start-up (Depressurisation) (TV-35-IG-00195) which includes the requirement that water injection should never be started up in both water injection wells at the same time, as this could lead to sand fill / clogging.	NV-CM-47-EPS-01	Process control trends show that water injection has not been started up in both wells at the same time	EPO-NV-06 EPO-NV-07	6.7
Use and management of corrosion and biocide treatment to maintain integrity of the PW system	NV-CM-48	Corrosion and biocide treatment is dosed to the PW system to maintain system integrity.	NV-CM-48-EPS-01	Chemical dosing records show corrosion and biocide are being / have been dosed to the PW system	EPO-NV-06 EPO-NV-07	6.7
Completed Environment and Economic Feasibility Study prior to permanent discharge decision	NV-CM-49	An Environment and Economic Feasibility study is undertaken either (i) Prior to a planned permanent overboard discharge from a state of reinjection; or (ii) When a temporary unplanned discharge is assessed as being at risk of escalation of its duration beyond those outlined in Table 6-20.	NV-CM-49-EPS-01	Environment and Economic Feasibility Study demonstrates that it was initiated: (i) Prior to a planned permanent overboard discharge from a state of reinjection (ii) When a temporary unplanned discharge was assessed as being at risk of	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		(iii) When forecast gas estimates show there is insufficient reservoir gas supply to supply fuel for remaining life of asset The study demonstrates that it is cost prohibitive (e.g. remediation costs are grossly disproportionate the financial net benefits of the remaining life of the asset) to remediate the event which has led to the PW discharge and that the PW discharge consequence from a permanent discharge remains ALARP and environmentally acceptable The Environment and Economic Feasibility study investigates multiple variables including: + Economic conditions, NV production performance and forecast + Remaining hydrocarbon reserves until end of field life. + Predicted PW discharge until end of field life + A review of technology relevant to the PW system capacity		escalation of its duration beyond those outlined in Table 6-20. (iii) When forecast gas estimates showed insufficient reservoir gas supply to supply fuel for remaining life of asset Documented study demonstrates that it is cost prohibitive to remediate the event which has led to the PW discharge and that the PW discharge consequence from a permanent discharge remains ALARP and environmentally acceptable		

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Detailed cost to remediate or repair the failure + A review of gas cap volumes. Demonstrating insufficient reservoir gas supply to supply fuel for remaining life of asset + Decommissioning impacts + A review and revisit of the ALARP and acceptability assessment and any technical studies + The identification of any new relevant industry regulations or guidance + A review of the environmental assessment and relevant existing approvals, any changes to environmental sensitivities (e.g. EPBC Act Listed Protected Matters), any newly identified literature studies and the environmental acceptability of permanent discharge.				
PW continuous improvement during permanent discharge	NV-CM-50	An annual review of permanent PW discharge scenario for continuous improvement ensures that Santos are actively assessing the availability of improvements in	NV-CM-50-EPS-01	PW Discharge Management Plan show an annual review of permanent PW discharge scenario for continuous improvement assessing	EPO-NV-06 EPO-NV-07	6.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		technology and engineering to improve PW discharge quality. The review aims to ascertain that permanent discharge of PW remains ALARP and environmentally acceptable. This includes a review of: + Technology available to reduce oil in water content + Technology to reduce PW discharge volumes + Production chemical improvements + Process / production tuning and optimisation + The identification of any new relevant industry regulations or guidance. + A review of the environmental assessment and relevant existing approvals, any changes to environmental sensitivities (e.g. EPBC Act Listed Protected Matters), any newly identified literature studies and the environmental acceptability of permanent discharge. Recommendations from the annual review are adopted with the aim to keep permanent discharge of PW ALARP and environmentally acceptable.		the availability of improvements in technology and engineering to improve PW discharge quality has occurred and that the that permanent discharge of PW remains ALARP and environmentally acceptable Records show recommendations with the aim to keep permanent discharge of PW ALARP and environmentally acceptable are adopted		

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Invasive Marine Species Management Plan	NV-CM-51	Vessels and the FPSO are managed to low risk in accordance with the Santos Invasive Marine Species Management Plan (EA-00-RI-10172) prior to movement/transit into or within the invasive marine species management zone, which requires: + Assessment of applicable vessels using the IMSMP risk assessment + The management of immersible equipment to low risk + Marine growth removal activity during hull class inspection is self-assessed in accordance with the Department of Agriculture In-water Cleaning Guidelines 2015 + ROV footage obtained during hull class inspections will be provided to an appropriately qualified biofouling expert to review the for the risk of IMS. + IMS inspection of the FPSO is undertaken prior to departure from shipyard so FPSO is deemed low IMS risk	NV-CM-51-EPS-01	Completed Risk Assessment demonstrating vessel is low risk Immersible equipment risk assessment demonstrating equipment is low risk Marine growth removal self-assessment completed ROV footage obtained during hull class inspection has been reviewed for IMS risk FPSO IMS inspection report shows low IMS risk prior to FPSO departure	EPO-NV-08	6.8 7.1
Anti-foulant system	NV-CM-52	Anti-foulant systems on the FPSO and vessels are maintained in compliance with International Convention on the Control of	NV-CM-52-EPS-01	Current International Anti-Fouling System Certificate in place for FPSO and vessels	EPO-NV-08	6.8 7.1

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		Harmful Anti-Fouling Systems on Ships.				
Ballast water management	NV-CM-53	Pursuant to the Biosecurity Act 2015 and Australian Ballast Water Management Requirements 2017, vessels carrying ballast water and engaged in international voyages shall manage ballast so that marine pest species are not introduced.	NV-CM-53-EPS-01	Records show Ballast Water Management is implemented Completed ballast water record book or log is maintained	EPO-NV-08	6.8 7.1
		FPSO complies with the IMO international convention for the control and management of ships ballast water and sediments, Regulation D1: + ballast water exchange conducted in an acceptable area + Locally sourced ballast water is of low risk and does not require any additional management (sourced at FPSO field location)	NV-CM-53-EPS-02	FPSO has International Ballast Water Management Certificate in place FPSO has an approved exemption in place from the Department of Agriculture not to comply with Regulation D2 Ballast water exchange has been conducted as per the FPSO Ballast Water Management Plan		
Visual inspection of DTM pickup: Use shared services vessels with neighbouring oil and gas	NV-CM-54	When the FPSO is off station for longer term absences (e.g. Shipyard campaign), vessel based visual inspections of the DTM pickup line arrangement occur during whale migration periods,	NV-CM-54-EPS-01	Records show that visual inspections have occurred on the DTM pickup line from shared vessel when feasible	EPO-NV-01	7.2

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
operators when FPSO is off station for longer absences (e.g. shipyard campaign).		when feasible using shared service vessels.				
Visual inspection of DTM pickup: dedicated vessel based monitoring to supplement frequency of shared services vessels.	NV-CM-55	When the FPSO is off station for longer term absences (e.g. Shipyard campaign), vessel based Visual inspections occur on the DTM pickup from a dedicated monitoring vessel four times a month during whale migration periods.	NV-CM-55-EPS-01	Records show that visual inspections have occurred on the DTM pickup line 4 times a month during whale migration periods	EPO-NV-01	7.2
Hazardous chemical management	NV-CM-56	For hazardous chemicals including hydrocarbons, the following standards apply to reduce the risk of an accidental release to sea from vessels and FPS0. + Storage containers closed when the product is not being used; + Storage containers labelled with the technical product name as per the safety data sheet (SDS); + Spills and leaks to deck, excluding storage bunds and drip trays, immediately cleaned up;	NV-CM-56-EPS-01	Audit and inspection records from vessels and FPS0 show compliance	EPO-NV-09	7.3 7.4

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Spill response equipment readily available.				
General chemical management	NV-CM-57	Safety data sheet (SDS) available for all chemicals to aid in the process of hazard identification and chemical management	NV-CM-57-EPS-01	Safety Data Sheet (SDS) is available for chemicals	EPO-NV-09	7.4
		Chemicals managed in accordance with SDS in relation to safe handling and storage, spill-response and emergency procedures, and disposal considerations	NV-CM-57-EPS-02	Audit and inspection records show chemicals are managed in accordance with SDS	EPO-NV-09	7.4
Spill response equipment	NV-CM-58	Spill response equipment is present on the FPSO and vessels to contain and recover spills on the deck thereby reducing potential for spills to reach the marine environment.	NV-CM-58-EPS-01	Audit and inspection records show spill response equipment is present on the FPSO and vessels	EPO-NV-09	7.4 7.6 7.9
Vessel spill response plan (SOPEP/SMPEP)	NV-CM-59	Vessels and FPSO have a shipboard oil pollution emergency plan (SOPEP) or shipboard marine pollution emergency plan (SMPEP) which outlines steps taken to combat spills.	NV-CM-59-EPS-01	Audit and inspection records show SOPEP / SMPEP is in place	EPO-NV-09 EPO-NV-10	7.4 7.7 7.9 7.10
Third-party ROV inspection and maintenance procedures	NV-CM-60	Preventative maintenance on ROV completed to reduce the risk of hydraulic fluid releases to sea.	NV-CM-60-EPS-01	Third party maintenance records	EPO-NV-09	7.4

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Inspection of hydrocarbon containing equipment	NV-CM-61	FPSO hydrocarbon containing equipment are maintained and functioning through inspection criteria and frequency as specified in PS-02 Hydrocarbon Containment: Hydrocarbon Containing Equipment (NV-00-RG-10053.08), which aims to prevent the uncontrolled release of hydrocarbons from topsides. The above PSAP provides details on: + Performance criteria + Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Equipment includes: + Topsides & offloading pressure containing equipment + Pumps + Engine Room and Cargo Equipment	NV-CM-61-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-10	7.8
		The Van Gogh and Coniston - Novara Subsea Inspection Monitoring and Maintenance Plan (IMM Plan) (TV-35-RU-10007) is	NV-CM-61-EPS-02	Campaign specific inspection records demonstrate ongoing inspection, and	EPO-NV-10	7.6 7.7 7.11

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		implemented to ensure subsea infrastructure integrity is maintained, reducing likelihood of release to the marine environment and to ensure Santos can meet obligations under s.572 of the OPGGS Act. The IMM Plan includes: + Inspection frequencies (see Section 2.13.1), including annual General Visual Inspection of the hydrocarbon containing elements of the subsea production system + Inspections methodologies (including General Visual Inspection and Cathodic Protection) + Post cyclone survey requirements, following a significant cyclonic event Covered equipment is presented in Table 2-9.		maintenance with the IMM Plan (TV-35-RU-10007) and an annual General Visual Inspection of the hydrocarbon containing elements of the subsea production system has been completed		
		Inspection criteria and frequency as specified in NV DTM System Inspection Prior to Reconnect Procedure (NV-22-IT-10001) prior to FPSO reconnection to DTM. The procedure provides details on the visual inspections and measurements required on the	NV-CM-61-EPS-03	Campaign specific inspection records	EPO-NV-10	7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		DTM Mooring Centre post cyclone, prior FPSO re-connection to assure that the DTM system integrity is maintained and functioning. Measurements and inspection depend on cyclone category and include: + General Inspection of the DTM Buoy Body (including depth and position) + Pull in Rope and Messenger line + Mooring System + Risers and Umbilical + Riser ESDV's				
Production operating procedures	NV-CM-62	Production operating procedures are in place to operate within the defined operating envelopes to maintain the integrity of the subsea infrastructure.	NV-CM-62-EPS-01	Production operating procedures are in place	EPO-NV-10	7.6 7.11
NOPSEMA accepted WOMP	NV-CM-63	The WOMP manages well integrity and all wells will be in compliance with the NOPSEMA accepted WOMP at all times. The WOMP includes control measures to manage well integrity risks to ALARP, including:	NV-CM-63-EPS-01	Regulatory-accepted WOMP includes control measures for well integrity. Incident records confirm no breach of containment. CMMS records demonstrate that inspection and maintenance activities	EPO-NV-10	7.6 7.11

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Barriers in place to isolate hydrocarbons from the marine environment + Inspection, monitoring and testing of barriers over the life of the well + Response to increases in well integrity risk + Notification and reporting requirements		are compliant with the WOMP.		
Testing of ESD and blowdown systems.	NV-CM-64	ESD and blowdown systems are maintained and functioning through function testing and inspection in accordance with: + PS-06 ESD and Blowdown: Emergency Shutdown Valves (ESDVs) (NV-00-RG-10053.06) + PS-07 ESD and Blowdown: Reservoir Isolation (Christmas Tree Valves) (NV-00-RG-10053.07) + PS-08 ESD and Blowdown: Safety Instrumented Systems (NV-00-RG-10053.08). The above PSAPs provide details on: + Performance criteria + Equipment to be tested	NV-CM-64-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-10	7.6 7.7 7.8 7.11

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Function testing in accordance with the PSAPs aims assure equipment can initiate blowdown and shutdown equipment) on hydrocarbon containing equipment to prevent / minimise release volumes to the environment.				
Blowdown and flare system	NV-CM-65	Flare system is maintained and functioning through function testing and inspections in accordance with PS-09 Blowdown and flare system (NV-00-RG-10053.09) to prevent escalation of loss of containment by the depressurisation of process inventories. The PSAP provides detail on: + Performance criteria + Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Equipment includes:	NV-CM-65-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-10	7.6 7.7 7.8

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Blowdown valves + Flare tip integrity + Nitrogen flare purge valves PS-09 aims to assure a functional blowdown system are available at all times that the associated plant is operational so escalation of spill events can be prevented by the depressurisation of process inventories via release to flare when initiated.				
Oil Pollution Emergency Plan (OPEP)	NV-CM-66	In the event of an oil spill to sea, the NV Operations OPEP (TV-00-RI-00003.02) requirements are implemented to mitigate environmental impacts.	NV-CM-66-EPS-01	Completed incident documentation shows OPEP implemented as applicable.	EPO-NV-10	7.6 7.7 7.8 7.9 7.10
Incident response plan detailing the requirements for preparedness and response to emergencies and crises to protect people and the environment.	NV-CM-67	In the event that the integrity of a pipeline/valve is compromised or there is an unplanned hydrocarbon release from: + the subsea infrastructure; or + the FPSO The Ningaloo Vision Incident Response Plan (QE-00-ZF-00044) is initiated to activate the Isolation of the flowline/ pipeline/ wells.	NV-CM-67-EPS-01	Completed incident documentation shows IRP implemented as applicable.	EPO-NV-10	7.6 7.7 7.8 7.9 7.10

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
Santos decommissioning framework implemented	NV-CM-68	No later than two years prior to the End of Field Life (EOFL) for the Van Gogh and Coniston Novara fields, Santos will have in place a Van Gogh and Coniston Novara fields Decommissioning Plan. The plan will detail how Santos' intends to meet the following commitments: + Permanently plug and abandon all Van Gogh and Coniston Novara wells while the title (WA-35-L) is still in force. + Remove or cause to have removed from the title all NV property brought into the title (WA-35-L), as authorised by Santos, while the title is still in force unless alternative arrangements have been made to the satisfaction of NOPSEMA. + Ensure through monitoring, and if required maintenance, (i) property can be removed when required and (ii) the ongoing presence of the property is not causing unacceptable environmental impacts or risks.	NV-CM-68-EPS-01	Completed Decommissioning Plan	EPO-NV-10	7.6 7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		The plan will include, as a minimum, the following details: + Regulatory obligations; + Stakeholder engagement plans; + Asset inventory, status and removal plans; + Decommissioning assumptions; + Study requirements; + A schedule including key activity, regulatory approval and project management milestones. + Risk assessments.				
Inspection and corrosion monitoring of risers	NV-CM-69	Offshore risers are maintained and functioning through meeting inspection/monitoring criteria, functionality and frequency as outlined in PS-03 Hydrocarbon Containment; Risers and Pipelines (NV-00-RG-10053.03), which assures the integrity of risers are fit for purpose and able to provide hydrocarbon containment. The PSAP provides detail on: + Performance criteria	NV-CM-69-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-10	7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Equipment includes: + Topsides risers + Annulus vent system + Subsea risers				
Mooring equipment integrity	NV-CM-70	Mooring equipment is maintained and functioning through function testing and inspections in accordance with PS – 28 Mooring (NV-00-RG-10053.28) which assures the FPSO remains within the DTM excursion limits and that the anchor chain assembly is certified through class certification, therefore the FPSO excursion cannot impact the risers leading to a release. The PSAP provides detail on: + Performance criteria + Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria	NV-CM-70-EPS-01	DTM position monitoring system records Class certification	EPO-NV-10	7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Work instructions Equipment includes: + DTM Position Monitoring + System + Hawser Hook + Mooring system				
DTM excursion limits	NV-CM-71	Electronic DTM excursion monitoring occurs and excursion is manually checked at intervals approximately every 6 hours.	NV-CM-71-EPS-01	DTM monitoring log	EPO-NV-10	7.7
		An excursion alarm is functioning and maintained in accordance with CMMS to alert the NV operator when DTM excursions ≥ 25m are exceeded.	NV-CM-71-EPS-02	CMMS FPSO records indicate status and	EPO-NV-10	
		DTM System Daily Monitoring and Immediate Actions Procedure (NV-22-IU-10001) immediate actions are followed in event of a DTM Buoy Excursion > 25 metres ALARM, including: + Prepare thruster and/or main engine for use + Increase DTM monitoring to 1 hour If after 6 hours of monitoring the DTM excursions are > 25m:	NV-CM-71-EPS-03	FPSO daily report indicates actions were taken in event of excursion >25 metres	EPO-NV-10	

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Confirm all 9 mooring top chains connected + Confirm all risers connected + Start thruster or main engine and "come up" on the Buoy to reduced excursions to below 15 metres (if required)				
Swivel functionality	NV-CM-72	Integrity of swivel and DTM buoy is managed, maintained and functioning in through function testing and inspections in accordance with PS-30 Swivel and DTM buoy (NV-00-RG-10053.30) which requires DTM Buoy inspection and turret /swivel system inspections so the FPSO can rotate whilst ensuring hydrocarbon containment of the swivel and DTM buoy system. The PSAP provides detail on: + Performance criteria + Equipment to be tested + Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Equipment includes: + Turret and swivel system	NV-CM-72-EPS-01	CMMS FPSO records indicate status	EPO-NV-10	7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ DTM buoy + DTM system				
SIMOPs plans and procedures	NV-CM-73	Vessels undertaking IMMR activities will undertake activities in accordance with SIMOPS Plan and activity specific work procedures to reduce potential for interactions between FPSO operation and IMMR activities.	NV-CM-73-EPS-01	Current SIMOPS Plans for vessels undertaking a project/campaign activity	EPO-NV-10	7.7
DTM Reconnection Procedure	NV-CM-74	DTM Reconnection Procedure (TV-22-IG-00061) is available and includes steps to prevent loss of containment during the reconnection of the FPSO to the DTM turret, including: + Reconnection stage instructions + Inspection checks + Reconnection criteria (i.e. weather, forecasts) + Pre-connection testing and familiarisation	NV-CM-74-EPS-01	Completed reconnection checklist	EPO-NV-10	7.7
DTM Dis-connection Procedure	NV-CM-75	DTM Disconnection Procedure (TV-22-IG-00062) includes steps to prevent and mitigate loss of containment during the disconnection of the FPSO to the DTM turret, including: + Disconnection criteria (i.e. weather, forecasts) + Inspection checks	NV-CM-75-EPS-01	Completed disconnection checklist	EPO-NV-10	7.7

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Depressurisation, flushing and purging of riser connections.				
Hull integrity	NV-CM-76	The FPSO: + maintains class certification; and + is double-sided design providing two physical barriers between cargo tanks and the marine environment for side impact, reducing potential for release in the event of collision	NV-CM-76-EPS-01	FPSO class certification is current	EPO-NV-10	7.8 7.9
Berthing and Terminal Handbook (TV-22-IG-00067)	NV-CM-77	Offtakes are undertaken within defined safe weather limits, as specified in the Berthing and Terminal Handbook (TV-22-IG-00067), which details limitations to swell height and wind speed, ultimately reducing risk of collision due to adverse weather. Note that the final berthing decision will be made by the Pilots and the FPSO.	NV-CM-77-EPS-01	Weather records for offtake period Daily report for offtake	EPO-NV-10	7.8 7.9 7.10
		Cargo loading operations will cease and the Offtake Tanker will be disconnected from the Terminal should the loads on mooring hawser become greater than those outlined in Berthing and Terminal Handbook (TV-22-IG-00067) In	NV-CM-77-EPS-02	Hawser load records	EPO-NV-10	7.8 7.9 7.10

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		order to prevent a release during loading.				
		Tanker berthing at the Terminal will not normally take place during hours of darkness (defined as ½ hour before sunrise and ½ hour after sunset) unless the OIM, Marine Supervisor, Pilot and the Offtake Master under their sole discretion determine and agree that local prevailing conditions are favourable to proceed with the berthing.	NV-CM-77-EPS-03	Daily report for offtake shows offtake occurred within limits	EPO-NV-10	7.8 7.9 7.10
		Use of the Terminal by an Offtake Tanker is subject to that Offtake Tanker's acceptance (Appendix 9) and undertaking to observe, perform and comply with the terms and conditions, procedures and requirements contained: + The Operations Manual; + Berthing and Terminal Handbook. Which includes, but not limited to the following, which will limit risk of	NV-CM-77-EPS-04	Offtake Tanker's acceptance to comply	EPO-NV-10	7.8 7.9 7.10

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		collision and unplanned hydrocarbon release events: + The Offtake Tanker approach (not any closer than 2nm to FPSO without express permission) + Navigation lights remaining as per international regulations during offtake + Communication establishment and communication protocol + Ballast requirements to ensure safe handling during adverse weather (the Offtake Tanker must be ballasted to at least 30% of its summer deadweight tonnage, with propeller (and bow thruster if fitted) submerged, unless advised to carry more ballast by the Pilot during adverse weather) + Specified mooring location and berthing requirements + Loading hose connection + Monitoring of cargo loading + Protocol during emergency situations.				

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		Prior to arrival at the Terminal, the Offtake Tanker a pre-offtake checklist is completed, as per Appendix 2, which includes items that confirm: + Agreed crude oil transfer plan is in place + Monitoring of transfer rates occur + Emergency response actions are agreed + Communications between the FPSO and Offtake Tanker can be maintained.	NV-CM-77-EPS-05	Completed Pre-offtake Checklist (Appendix 2)	EPO-NV-10	7.8 7.9 7.10
		An initial safety inspection is be conducted by the Pilot and or Mooring Master on boarding of the offtake tanker to ensure it is fit (in a safe and environmentally sound manner) to receive the Van Gogh crude blend.	NV-CM-77-EPS-06	Appendix 2 of Berthing and Terminal Handbook (TV-22-IG-00067) has been completed and shows safety inspection occurred on pilotage	EPO-NV-10	7.8 7.9 7.10
Offtake Operational and Pilotage Procedure (NV-91-IG-10010.03)	NV-CM-78	FPSO will complete a pre-berthing toolbox talk (Appendix 5 - checklist) before each offtake which includes a check of the key controls, functioning equipment and communication which mitigate against vessel to vessel interaction	NV-CM-78-EPS-01	Completed Appendix 5 – checklist prior to offtake	EPO-NV-10	7.8 7.10

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		and loss of hydrocarbon containment.				
		An Offtake Operations Checklist (Appendix 1) will be completed which includes a check that the key equipment / communications mitigating a release to the environment is in place, this includes the following checks: + Floating hose reel has been tested + Spill response kits are on location + Floating hose O ring inspected + Hose connected + Offtake operations communications checked + All scupper plugs are in	NV-CM-78-EPS-02	Completed Appendix 1 Offtake Operations Checklist, prior to offtake	EPO-NV-10	7.8

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		The floating hose is of double carcass structure and fitted with a quick release coupling on the connection between the floating hose and the hose reel	NV-CM-78-EPS-03	Records show that the floating hose is of double carcass structure and fitted with a quick release dry-break coupling	EPO-NV-10	7.8
		A specialist qualified Pilot shall undertake the pilotage of the Offtake Tanker to ensure offtake tanker berthing and unberthing operations occur in a safe manner in keeping with good seamanship practices.	NV-CM-78-EPS-06	The Berthing Record portion of Appendix 1 of the Offtake Operations and pilotage procedure (NV-91-IG-10010.03) is completed and shows Pilot was onboard.	EPO-NV-10	7.8 7.9 7.10
Blowdown and pressure safety valves	NV-CM-79	Emergency shutdown systems and shutdown/ safety valves are maintained and functioning in accordance with PS-10 ESD and Blowdown: Pressure safety valves (NV-00-RG-10053.10). PS-10 applies to all PSVs on pressure containing equipment and pipework to ensure integrity and prevent a loss of containment from equipment and piping by controlled disposal via the flare systems or an alternative safe location rather than discharge to the environment. The PSAP provides detail on: + Performance criteria + Equipment to be tested	NV-CM-79-EPS-01	CMMS FPSO records indicate testing / inspection schedules and status	EPO-NV-10	7.8

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
		+ Nominal testing frequencies / intervals + Pass / fail criteria + Work instructions Equipment includes: + Pressure safety valves + Pressure vacuum valves + Liquid PV Breakers				
Radio communication prior to entering PSZ	NV-CM-80	Communications between the FPSO and vessels entering the PSZ is established prior to vessels entering.	NV-CM-80-EPS-01	Records show communications between the FPSO and vessels entering the PSZ have been established	EPO-NV-10	7.8 7.9 7.10

Control Measure	Control Measure Ref no.	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	EPO Reference (Table 8-1)	Relevant Section of this EP
NV Bunkering Operation Procedure	NV-CM-81	Bunkering activities follow the requirements of NV Bunkering operation procedure (NV-91-IG-10006.03) which includes key requirements to prevent spills to the environment such as: + When bunkering activities can occur + Roles and responsibilities for bunkering operations + dry break coupling and breakaway coupling used + bunkering activity communication requirements + Bunker hose undergoes hydrostatic leak testing	NV-CM-81-EPS-01	Completed bunkering checklist CMMS FPSO records indicate status	EPO-NV-10	7.9
Low Pressure Alarm on Distributed Control System (DCS) for GLJ/flowline	NV-CM-82	Low Pressure Alarm on Distributed Control System (DCS) for GLJ/flowline to alert operators to drops in gas pressure in Gas Lift Jumpers and on Gas Flowline.	NV-CM-82-EPS-01	CMMS records	EPO-NV-10	7.11

8.5 Leadership, Accountability and Responsibility

OPGGS(R) 2009 Requirements
Regulation 14(4)
The implementation strategy must establish a clear chain of command, setting out the roles and responsibilities of personnel in relation to the implementation, management and review of the environment plan, including during emergencies or potential emergencies

While the Santos Chief Executive Officer (CEO) has the overall accountability for the implementation of the Santos Management System and Santos Environment Health and Safety Policy, the Santos Production Manager - NV is accountable for ensuring implementation, management and review of this EP.

Assets is accountable for ensuring implementation, management and review of this EP.

Effective implementation of this EP will require collaboration and cooperation among Santos and its contractors. This is reflected in **Figure 8-1** and **Table 8-3**., which sets out the roles and responsibilities of personnel in relation to the implementation, management and review of the EP.

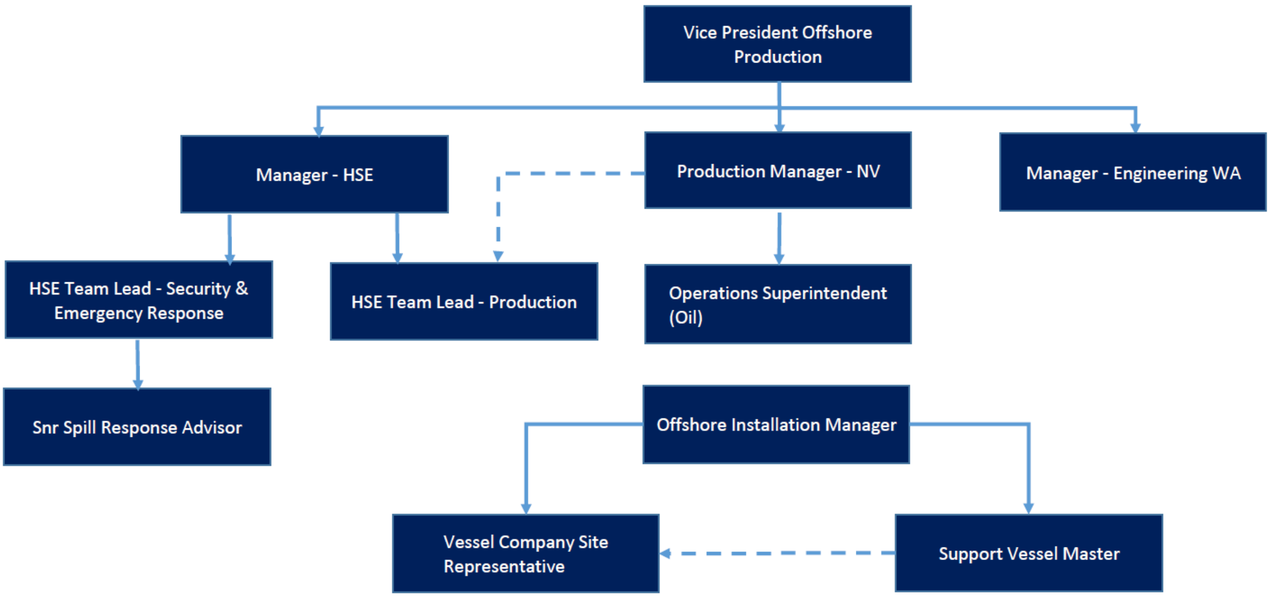

Figure 8-1: Organisation Chart

Table 8-3: Chain of Command, Key Leadership Roles and Responsibilities

Role	Responsibilities
Perth Office-based Roles	
VP – Offshore Production	Has overall responsibility for: + Complying with the EP and Santos policies and procedures; + Approving budgets to meet EP commitments; + Ensuring accurate reporting of environmental incidents; and + Ensuring company has contractual provisions in place to enable rapid response to oil spill incidents.
Production Manager - NV	Has overall responsibility for: + Implementing the EP and Santos policies and procedures; + Ensuring the appropriate level of budget, planning and execution of activities is in place to meet EP commitments; + Ensuring appropriate checks completed prior to mobilising support vessels; + Approving Environmental Management of Change (MoC) documents; + Ensuring environmental incidents are appropriately investigated; and + Applying appropriate compliance mechanisms to prevent breaches of this EP.
Operations Superintendent (Oil)	Has responsibility for: + Ensuring that all relevant plans, commitments and procedures are available to personnel; + Implementing the CMMS; + Ensuring appropriate level of risk assessment has been completed; + Approving procedures and work instructions; + Developing resourcing plans; and + Interfacing between onshore and offshore teams.
Manager - Engineering WA	Has overall responsibility for: + Subsea maintenance and integrity management plan; + Providing engineering support to the operational activities; and + Providing technical assurance.
Manager HSE	Has overall responsibility for: + Ensuring incident preparedness and response arrangements meet Santos and regulatory requirements + Approving the OPEP + Providing ongoing resources to maintain compliance with the OPEP and other Santos incident response requirements

Santos

Role	Responsibilities
HSE Team Lead – Security Emergency Response	Has overall responsibility for: + Overarching incident and crisis management responsibility + Manage the CMT and IMT personnel training program + Review and assess competencies for CMT, IMT, and field-based IRT members + Manage the Duty roster system for CMT and IMT personnel + Manage the maintenance and readiness of incident response resources and equipment
HSE Team Lead - Production	Has overall responsibility for: + Complying with the Santos Environment Health and Safety Policy and this EP; + Providing operational HSE oversight and advice; + Ensuring adequate resources are provided for HSE support; + Facilitating the development and implementation of environmental management of change documents; + Ensuring EP-required reporting is accurate and timely; + Ensuring environmental incidents are appropriately investigated; + Ensuring that appropriate enforcement mechanisms to prevent breaches of this EP are implemented; and + Providing advice to ensure environmental incident reporting meets regulatory requirements (as outlined in the EP) and the Santos internal incident reporting and investigation procedure.
Senior Oil Spill Response Advisor	Has overall responsibility for: + Provides upfront and ongoing guidance, framework, and direction on preparation of this OPEP + Develops and maintains arrangements and contracts for incident response support from 3rd-parties + Develops and define objectives, strategies and tactical plans for response preparedness defined in this OPEP and IRP + Undertaking assurance activities on arrangements outlined within the OPEP
Field based Roles	
Offshore Installation Manager	Has responsibility for: + Implementing EP commitments; + Ensuring personnel competency; + Ensuring compliance with procedures and work instructions; + Providing the site focal point for onshore/offshore communications; + Approving vessels entering the field; + Reporting all incidents and potential hazards; + Leading site-based incident response; and + Implementing corrective actions arising from environmental incidents and audits.

Role	Responsibilities
Vessel – Company Site Representative	Has responsibility for: + Reporting all incidents and potential hazards to the OIM; + Controlling and implementing risk reduction measures during site-based activities; + Providing site response to incidents to minimise environmental impact (if safe to do so); + Ensuring all personnel working on FPSO are knowledgeable about the specific risks of the tasks being undertaken; and + Ensuring a high standard of housekeeping is maintained at work locations.
Support Vessel Master	Has overall responsibility for: + Implementing and ensuring compliance with relevant environmental legislative requirements, EP commitments and operational procedures on the support vessel; + Maintaining clear communication with the crew and personnel; + Communicating hazards and risks to the workforce; + Monitoring daily activities on the vessel to ensure that the relevant environmental legislative requirements, EP commitments and operational procedures are being followed; + Maintaining their vessels to all regulatory and class requirements; + Maintaining their vessel in a state of preparedness for emergency response; and + Reporting environmental incidents to the OIM and ensuring follow-up actions are carried out.

8.6 Workforce Training and Competency

OPGGS(R) 2009 Requirements
Regulation 14(5)
The implementation strategy must include measures to ensure that each employee or contractor working on, or in connection with, the activity is aware of his or her responsibilities in relation to the environment plan, including during emergencies or potential emergencies, and has the appropriate competencies and training

This section describes the mechanisms that will be in place so that each employee and contractor is aware of his or her responsibilities in relation to the EP and has appropriate training and competencies.

8.6.1 Inductions

All personnel that arrive on the facilities and crew on support vessels will complete an induction that will include a component addressing their EP responsibilities. Induction attendance records for all personnel will be maintained. Inductions will include relevant information on:

+ Environment Health and Safety Policy;
+ Regulatory regime (NOPSEMA regulations);
+ Operating environment (e.g., nearby protected marine areas, sensitive environmental periods);
+ Activities with highest risk (e.g., invasive marine species and hydrocarbon releases);

+ EP commitments (e.g. **Table 8-2**);
+ Incident reporting and notifications;
+ Regulatory compliance reporting;
+ Management of change process for changes to EP activities; and
+ Oil pollution emergency response (e.g. OPEP requirements).

8.6.2 Training and Competency

All members of the workforce, either onshore, on the facilities or on support vessels will complete relevant training and hold qualifications and certificates for their role. Measures in place to ensure that on-shore personnel have the appropriate competencies and training as required by regulation 14(5) include the development and implementation of skill matrices Perth Office Competency Matrix – Oil Asset Department (QE-92-IG-10024). The Competency Matrix document outlines the required Competency's for each position identified in the Oil Assets Department. The Matrix includes the relevant job descriptions and describes how it is the responsibility of the Production Manager - NV, to ensure the competencies of the department positions are maintained and up to date.

For each Santos position (onshore and offshore), training matrices indicate the competencies required for the job role.

Santos and its contractors (e.g., support vessel, technical service providers) are individually responsible for ensuring that their personnel are qualified and trained. The systems, procedures and responsible persons will vary and will be managed through the use of online databases, desktop matrix, staff on-boarding processes, training departments, etc. Personnel qualification and training records will be sampled before and/or during an activity.

8.6.3 Workforce Involvement and Stakeholder Communication

Daily operational meetings will be held offshore at which HSE will be a standing agenda item. It is a requirement that supervisors attend daily operational meetings and that all personnel attend daily toolbox or pre-shift meetings.

Toolbox meetings will be regularly held offshore to plan jobs and discuss work tasks, including HSE risks and controls.

HSE performance will be monitored and reported during operations, and performance metrics (such as the number of environmental incidents) will be regularly communicated to the workforce. Workforce involvement and environmental awareness will also be promoted by encouraging offshore personnel to report marine fauna sightings and marine pollution (e.g., oil on water, dropped objects).

8.7 Maintenance Management System

Santos uses a Computerised Maintenance Management System (CMMS) for offshore and onshore plant inspection. The planned maintenance management procedures are also supported by the Maintenance Management System. The objective of the Maintenance Management System is to ensure that the plant and associated equipment are fit for purpose, are safe to operate and are environmentally compliant for the life of the asset.

The Santos Computer Maintenance Management System (CMMS) provides the information required to determine risk or criticality-based maintenance requirements. The scheduling (including deferral), of maintenance activities is undertaken on the basis of criticality of equipment and allows works to be rescheduled based on the areas most critical for safety, environment, compliance and production.

This results in effective and efficient practices to maximise reliability and availability of the plant. A preventive maintenance plan is incorporated into the CMMS. The preventive maintenance plan includes:

+ All routine inspections;

+ All statutory inspections; and
+ All maintenance carried out on a usage basis such as machine running hours

8.8 Asset Management

Santos' management system defines business expectations and requirements for the management of assets to ensure their strategic and economic value is optimised through the asset life cycle, while preventing harm to people and the environment.

As part of their assets life cycle management requirements, Santos assets are required to have a decommissioning strategy and plan.

Santos' current decommissioning strategy is based on removing property at the end-of-field-life (EOFL) and this is consistent with the Coniston Novara Field Development Plan (accepted by NOPTA 30 November 2012) and the Van Gogh Field Development Plan (accepted 4 Sept 2008 by Department of Industry and Resources (WA)).

Santos' current estimate for EOFL for the existing NV Operations is 2025 to 2028. EOFL is reviewed annually as part of Santos' structure reserves audit process. However, this is subject to change as EOFL is dependent on multiple variables including economic conditions, production performance and forecast, and reserves.

Opportunities to extend the life of the NV Operations and associated subsea infrastructure through future developments and opportunities will also be regularly considered. As such, property may remain beyond the NV EOFL and decommissioning activities may be staged.

Santos will have in place a Decommissioning Plan for the Van Gogh, and Coniston and Novara fields, no later than two years prior to the EOFL (refer to **Section 2.15**).

It is through the development and implementation of the Decommissioning Plan that Santos will meet its obligations under s. 572 (3) of the OPGGS Act 'to remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations'.

8.9 Emergency Preparedness and Response

OPGGS(E)R 2009 Requirements
Regulation 14(8)
The implementation strategy must contain an oil pollution emergency plan and provide for the updating of the plan.

Vessels are required to have and implement incident response plans, such as an emergency response plan and SMPEP or SOPEP. Regular incident response drills and exercises (e.g., as defined in emergency response plan, SMPEP or SOPEP) will be carried out on support vessels to refresh the crew in using equipment and implementing incident response procedures as per the vessel class requirements.

Santos will implement NV Operations OPEP (TV-00-RI-00003.02) in the event of a significant hydrocarbon spill. To maintain a state of oil spill preparedness, personnel with OPEP responsibilities will be made aware of their obligations, an oil spill response exercise and training schedule will be maintained, oil spill response equipment will be maintained, contracts with critical equipment and personnel suppliers will be managed, and agreements will be in place with national regulatory agencies for support in oil spill response.

8.10 Incident Reporting, Investigation and Follow-up

OPGGSR 2009 Requirements
Regulation 14(2)
The implementation strategy must:

(a) state when the titleholder will report to the Regulator in relation to the titleholder's environmental performance for the activity; and (b) provide that the interval between reports will not be more than 1 year. Note: Regulation 26C requires a titleholder to report on environmental performance in accordance with the timetable set out in the environment plan.
Regulation 14(7)
The implementation strategy must provide for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

All personnel will be informed through inductions and daily operational meetings of their duty to report HSE incidents and hazards. Reported HSE incidents and hazards will be shared during daily operational meetings, and HSE incidents and hazards will be documented in the incident management systems as appropriate. HSE incidents will be investigated in accordance with the Incident Reporting and Investigation Procedure (QE-91-IF-00002).

Environmental recordable and reportable incidents will be reported to NOPSEMA and to other regulators as required in accordance with **Table** 8-4. The incident reporting requirements will be provided to all crew on board the facilities and support vessels during induction with special attention to the reporting time frames to provide for accurate and timely reporting.

For the purposes of this activity, in accordance with OPGGS(E)R 2009:

+ A recordable incident, for an activity, means a breach of an environmental performance outcome or environmental performance standard, in the environment plan that applies to the activity, that is not a reportable incident; and
+ A reportable incident, for an activity, means an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage.

For the purposes of this EP, a reportable incident is an incident that is assessed to have an environmental consequence of moderate or higher in accordance with the Santos environmental impact and risk assessment process outlined in **Section 5**.

8.11 Reporting and Notifications

OPGGS(E)R 2009 Requirements
Regulation 14(2)
The implementation strategy must: + state when the titleholder will report to the Regulator in relation to the titleholder's environmental performance for the activity; and + provide that the interval between reports will not be more than 1 year.
Regulation 14(7)
The implementation strategy must provide for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

8.11.1 Notifications and Compliance Reporting

Regulatory other notification requirements, and compliance reporting requirements are summarised in **Table 8-4.**

Table 8-4: Notification and reporting requirements

Initiation	Required Information	Timing	Type	Recipient
During the Activity				
OPGGS(E) Regulation 26B – Recordable Incidents NOPSEMA must be notified of a breach of an environmental performance outcome or standard, in the environment plan that applies to the activity that is not a reportable incident.	Complete NOPSEMA's Recordable Environmental Incident Monthly Report form.	The report must be submitted as soon as practicable after the end of the calendar month, and in any case, not later than 15 days after the end of the calendar month.	Written	NOPSEMA
OPGGS(E) Regulation 16(c), 26 & 26A – Reportable Incident NOPSEMA must be notified of any reportable incidents. For the purposes of Regulation 16(c), a reportable incident is defined as: An incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage.	The oral notification must contain: + All material facts and circumstances concerning the reportable incident known or by reasonable search or enquiry could be found out; and + Any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident; and + The corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident.	As soon as practicable, and in any case not later than 2 hours after the first occurrence of a reportable incident, or if the incident was not detected at the time of the first occurrence, at the time of becoming aware of the reportable incident.	Oral	NOPSEMA
	A written record of the oral notification must be submitted. The written record is not required to include anything that was not included in the oral notification.	As soon as practicable after the oral notification.	Written	NOPSEMA NOPTA DMIRS
	A written report must contain:	Must be submitted as soon as practicable, and in any case not later than 3 days after the first occurrence of the	Written	NOPSEMA NOPTA

Initiation	Required Information	Timing	Type	Recipient
	+ All material facts and circumstances concerning the reportable incident known or by reasonable search or enquiry could be found out; and + Any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident; and + The corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident; and + The action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future. Consider reporting using NOPSEMA's Report of an Accident, Dangerous Occurrence or Environmental Incident form.	reportable incident unless NOPSEMA specifies otherwise. Same report to be submitted to NOPTA and DMIRS within 7 days after giving the written report to NOPSEMA.		DMIRS
OPGGS(E) Regulation 26C –Environmental Performance NOPSEMA must be notified of the environmental performance at the intervals provided for in the EP.	Report must contain sufficient information to determine whether or not environmental performance outcomes and standards in the EP have been met.	Annual performance report to be submitted to NOPSEMA annually from the date of acceptance of this EP.	Written	NOPSEMA
Under the MoU between Santos and AMSA	Titleholder agrees to notify AMSA of any marine pollution incident[7]	Within 2 hours of incident	Oral	AMSA

[7] For clarity and consistency across Santos regulatory reporting requirements Santos will meet the requirement of reporting marine oil pollution by reporting oil spills assessed to have an environmental consequence of moderate or higher in accordance with Santos's environmental impact and risk assessment process outlined in **Section 5**.

Initiation	Required Information	Timing	Type	Recipient
	POLREP and SITREP available online (refer OPEP)	POLREP as requested by AMSA following verbal notification SITREP as requested by AMSA within 24 hours of request	Written	AMSA
Notification of the event of oil pollution within a marine park or where an oil spill response action must be taken within a marine park.	Not specified, however should include details of event and response actions being undertaken with the marine park.	So far as reasonably practicable prior to response action being written.	Not defined.	Director of National Parks
If marine pests or disease are suspected this must be reported to DPIRD.	Notification of any suspected marine pests or diseases including any organism listed in the Western Australian Prevention List for Introduced Marine Pests and any other non-endemic organism that demonstrates invasive characteristics.	Within 24 hours.	Oral	DPIRD FishWatch
Any harm or mortality to EPBC Act- listed threatened marine fauna.	Notification of any harm or mortality to an EPBC listed species of marine fauna whether attributable to the activity or not.	Within 7 days to EPBC.permits@environment.gov.au.	Written	DoAWE
Any harm or mortality to fauna listed as threatened under the WA Biodiversity Conservation Act 2016	Notification of any harm or mortality to fauna listed as a threatened species under the WA Biodiversity Conservation Act 2016 as a result of Santos activities.	A fauna report will be submitted to DBCA Within 7 days to fauna@dbca.wa.gov.au	Written	DBCA
Marine Fauna Sighting Data.	Marine fauna sighting data recorded in the marine fauna sighting database.	Not later than 3 months of the end of the activity.	Written	DoAWE
Any ship strike incident with cetaceans will also be reported to the National Ship Strike database.	Ship strike report provided to the Australian Marine Mammal Centre: https://data.marinemammals.gov.au/report/shipstrike	As soon as practicable	Written	DoAWE
Impacts to marine mammals or turtles in reserves.	Notification of any incidence of entanglement, boat collisions and stranding of marine mammals in the reserves and any incident of turtle mortality and incidents of	Within 48 hours.	Written	DBCA

Initiation	Required Information	Timing	Type	Recipient
	entanglement in the reserves as detailed in the Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves.			
All actual or impending MOP incidents that are in, or may impact, State waters resulting from an offshore petroleum activity	Notification of actual or impending spillage, release or escape of oil or an oily mixture that is capable of causing loss of life, injury to a person or damage to the health of a person, property or the environment[7].	Within 2 hours	Verbal	DoT
	WA DoT POLREP and SITREP available online (refer OPEP).	As requested by DoT following verbal notification	Written	DoT
Planned 2020 Shipyard Campaign	Santos to notify Defence of dates when NV FPSO will leave the operational area, and when it will return. Notification to offshore.petroleum@defence.gov.au	Prior to leaving operational area and prior to return to operational area	Written	Defence
Project vessels are in the operational area for specific project/campaign type activities (not day to day support or supply).	Santos to notify Australian Hydrographic Service of dates when project vessels are in the operational area for specific project/campaign type activities.	Three weeks where practicable	Written	Australian Hydrographic Service

8.11.2 Monitoring and Recording Emissions and Discharges

Vessel based discharges to the marine environment associated with this activity will be recorded and controlled in accordance with requirements under the relevant marine orders.

Santos and support vessel contractors will maintain records so that emissions and discharges can be determined or estimated. Such records will be maintained for a period of five years. Contractors are required to make these records available upon request.

Santos records discharges or emissions (where practicable), to the environment as described in **Table 8-5**.

Table 8-5: Recorded Emissions and Discharges

Discharge/emission	Parameter	Record	Recording frequency
Atmospheric emissions	Green House Gasses Total Volumes (carbon dioxide (CO^2), methane (CH^4) and nitrous oxide (N_20))	Production Reporting System (PRS), Estimated for NGERS reporting and put into and annual compliance report.	Annually
Chemicals (discharged to marine environment as per Section 6.6)	Volume	Chemical Risk Assessment. Volumes used will be estimated based on known inventories	For every chemical use with a fate to the marine environment
Oily water	Volume and location (support vessels)	Oil Record Book or equivalent report	For every discharge
Garbage (including foodscraps)	Volume and location (support vessel)	Garbage Record Book	For every discharge
Sewage	Volume and location (support vessel)	Sewage Record Book	For every discharge
Unplanned discharge of solid waste	Volume	Incident report	For every discharge
Unplanned discharge of liquid hazardous materials	Volume	Incident report	For every discharge
Unplanned hydrocarbon release	Volume	Incident report	For every discharge

PW monitoring is in accordance with the PW Adaptive Management Plan (**Appendix H**).

8.12 Document Management

8.12.1 Information Management and Document Control

This EP and OPEP, as well as approved management of change documents, are controlled documents; and current versions will be available on the Santos intranet. Santos contractors are also required to maintain current versions of HSE documents including this EP and OPEP on their facilities.

Environmental performance outcomes and standards will be measured based on the measurement criteria listed in **Table 8-2.** Such records will be maintained for a period of five years. Contractors are required to make these records available upon request.

8.12.2 Management of Change

Proposed changes to this EP and OPEP will be managed in accordance with the Santos Environment Management of Change Procedure (EA-91-IQ-10001), the “MoC process”. The MoC process provides a systematic approach to initiate, assess, document, approve, communicate and implement changes to EPs and OPEPs.

The MoC process considers Regulations 7, 8 and 17 of the OPGGS(E)R 2009 and determines if a proposed change can proceed and the manner in which it can proceed. The MoC process will determine whether a revision of the EP is required and whether that revision is to be submitted to NOPSEMA. For a change to proceed, the associated environmental impacts and risks must be demonstrated to be acceptable and ALARP. Additional stakeholder consultation may be required, depending on the nature and scale of the change. Additional information on the MoC process is provided in **Figure 8-2.**

The MoC process also allows for the assessment of new information that may become available after EP acceptance, such as new management plans for Australian marine parks, new recovery plans or conservation advice for species, and changes to the EPBC Protected Matters Search results. If a review identifies new information, this is treated as a “Change that has an impact on Environment Plan”, and the MoC process is followed accordingly.

Accepted MoCs become part of the in-force EP or OPEP and are tracked on a register and made available on the Santos intranet. Where appropriate, the EP compliance register will be updated so that control measure or environmental performance standard changes are communicated to the workforce and implemented. Any MoC will be distributed and implemented as per the actions within the MoC form.

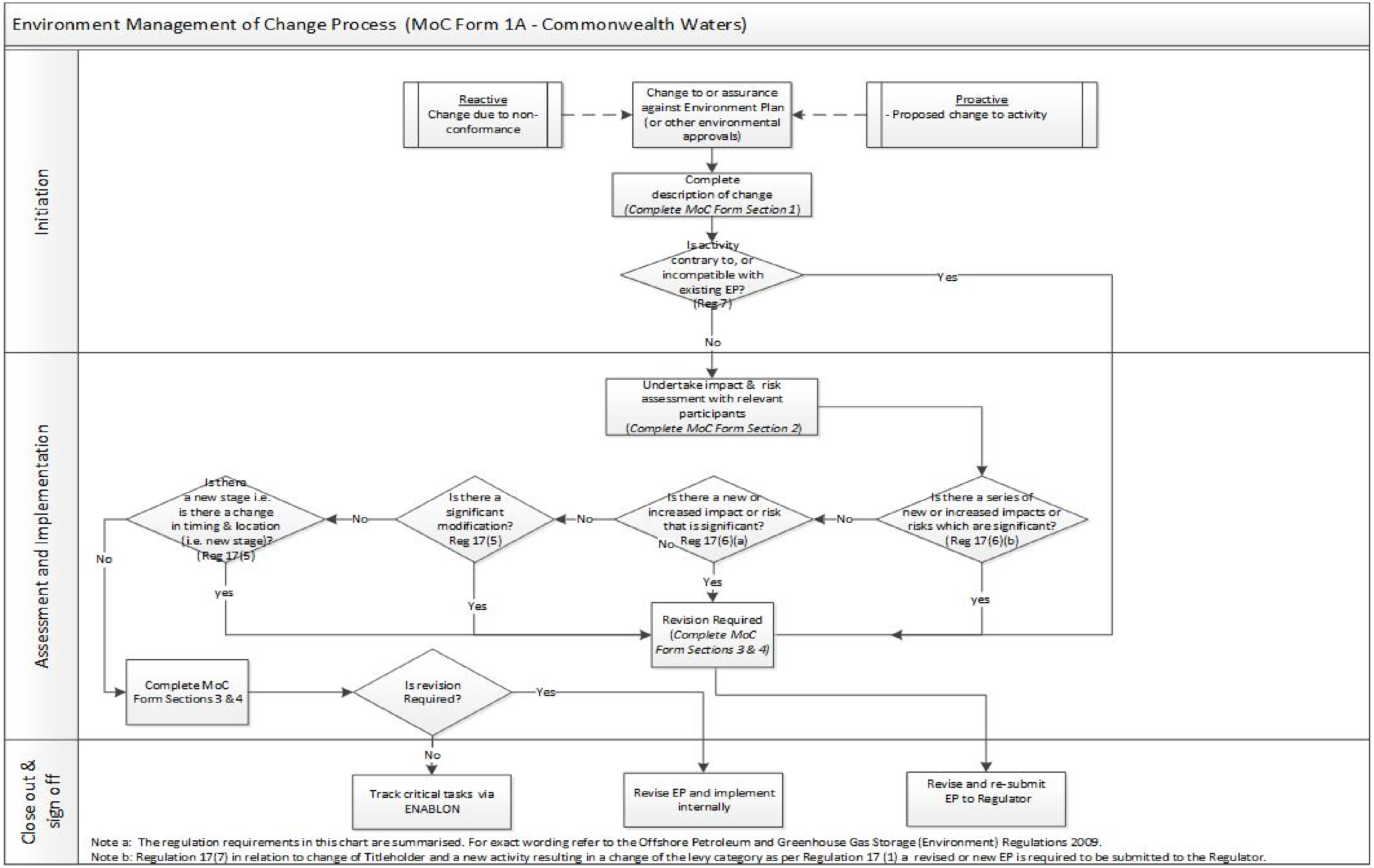

Figure 8-2: Environment Management of Change Process

8.12.3 Reviews

This EP has assessed impacts and risk across the entire operational area, during any time of the year, for planned and unplanned events given the nature of the 24/7 operations.

It is recognised that the following may change over the validity of this EP:

+ Legislation;
+ Businesses conditions, activities, systems, processes and people;
+ Industry practices;
+ Science and technology; and
+ Societal and stakeholder expectations.

To ensure that Santos maintains up-to-date knowledge of the industry, legislation and conservation advice, the following tasks are undertaken:

+ Maintaining membership of APPEA, which provides a mechanism for communicating potential changes in legislation, industry practice and other issues that may affect EP implementation to relevant personnel in Santos;
+ Undertaking spill response exercises in accordance with the OPEP to check spill response arrangements and capability are adequate;
+ Identifying and updating relevant stakeholders under this EP via the mechanisms outlined in **Section 4.2**;
+ Review of the Values and Sensitivities within the EMBA which includes completing a new EPBC Protected Matters Search, reviewing **Appendix D1** against relevant legislation to capture and review any relevant updates and incorporate as required, and reviewing any recently known published relevant scientific papers;
+ Subscription to NOPSEMA's "The Regulator" issued quarterly;
+ Subscriptions to various regulator updates; and
+ Regular liaison meetings with regulators.

Through maintenance of up to date knowledge, changes are identified. If the changes have a significant impact on the activity or risks described and assessed in this EP, the EP will be reviewed and any changes required documented in accordance with the Santos Environment Management of Change Procedure (EA-91-IQ-10001) (**Section 8.12.2**).

8.13 Audits and Inspections

OPGGS(R) 2009 Requirements
Regulation 14(6)
The implementation strategy must provide for sufficient monitoring, recording, audit, management of nonconformance and review of the titleholder's environmental performance and the implementation strategy to ensure that the environmental performance outcomes and standards in the environment plan are being met.

8.13.1 Audits

Santos audit plans and schedules are reviewed and updated at the beginning of each calendar year and cover all Santos facilities and activities. The Santos audit schedule may be amended to accommodate operational priorities, activity risk, personnel availability or high audit demand during certain periods (e.g., regulatory audits, contractor audits).

Audits will be undertaken in a manner consistent with the Santos Assurance Standard (QE-91-ZF-100073).

Audit scope typically includes a selection of control measures and environmental performance standards and outcomes. However, audits may also include other parts of the EP.

Audits findings may include opportunities for improvement and non-conformances. Audit non-conformances are managed as described in **Section 8.13.3**.

8.13.2 Inspections

During an activity, HSE inspections will be conducted to identify hazards, incidents and EP non-conformances to check compliance against all of the environmental performance outcomes and standards of this EP (**Table 8-2**). Any in-field opportunities for improvement or corrective actions will be discussed during the inspection with the work area supervisor and/or crew. Inspection reports will be distributed for review to Santos relevant personnel (e.g., Operations Superintendent, Santos on-board representatives), and HSE Department representatives.

8.13.3 Non-conformance Management

EP non-conformances will be addressed and resolved by a systematic corrective action process as outlined in the Santos Assurance Standard (QE-91-ZF-10007). Non-conformances arising from audits and inspections will be entered into the Santos incident and action tracking management system. Once entered, corrective actions, time frames and responsible persons (including action owners and event validators) will be assigned. Corrective action ‘close out’ will be monitored using a management escalation process.

8.13.4 Continuous Improvement

For this EP, continuous improvement will be driven by the list below, and may result in a review of the EP with changes applied in accordance with **Section 8.12.2**:

+ Improvements identified from the review of business-level HSE key performance indicators;
+ Actions arising from the Santos and departmental HSE improvement plans;
+ Corrective actions and feedback from HSE audits and inspections, incident investigations and after-action reviews;
+ Opportunities for improvement and changes identified during pre-activity reviews and MoC documents
+ Actions taken to address concerns and issues raised during the ongoing stakeholder consultation management process (**Section 4**); and
+ Identified continuous improvement opportunities will be assessed in accordance with the Santos MoC process (**Section 8.11.2**) to ensure any potential changes to this EP, or OPEP, are managed in accordance with the OPGGS(E)R 2009 and in a controlled manner.

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Appendix A. Santos Environment Health and Safety Policy

Environment, Health & Safety

Policy

Our Commitment

Santos is committed to being the safest oil and gas operator in Australia and preventing harm to people and the environment

Our Actions

We will:

1. Integrate environment, health and safety management requirements into the way we work and ensure that we comply with all relevant environmental, health and safety laws
2. Include environmental, health and safety considerations in business planning, decision making and asset management processes
3. Identify, effectively control, monitor and ensure awareness of risks that have the potential for serious harm to people and the environment
4. Lead a strong and consistent environment, health and safety culture across all aspects of business
5. Work proactively and collaboratively with our stakeholders and the communities in which we operate
6. Set, measure, review and monitor objectives and targets to demonstrate proactive processes in place to continuously reduce the risk of harm to people and the environment
7. Report publicly on our environmental health and safety performance

Governance

The Environment Health Safety and Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Jodie Hatherly, General Counsel & Vice President, Legal, Risk and Governance		
Approved by:	The Board	Version:	2

APPROVED 28 November 2018

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Appendix B. Relevant International, Commonwealth and State Legislation

Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act)

The EPBC Act is administered by the Commonwealth Department of the Agriculture, Water and the Environment (DAWE). The EPBC Act protects matters of national environmental significance (MNES) across Australia and protects the environment in relation to actions on (or impacting upon) Commonwealth land or waters. When a person proposes to take an action that they consider may need approval under the EPBC Act, they must refer the proposal to the Commonwealth Minister for Environment. The Petroleum Activities for the Van Gogh and Coniston Novara development are governed by the primary approval for the Van Gogh and Coniston and Novara Fields.

In February 2014, environmental regulation of petroleum activities in Commonwealth waters became streamlined, by making NOPSEMA the sole Commonwealth regulator for these activities. The document *"Streamlining environmental regulation of petroleum activities in Commonwealth waters Information Paper IP1382"* states that the streamlining provides the following benefits:

- Assessment and approval of petroleum activities in Commonwealth waters under the EPBC Act is no longer necessary. Impacts on matters protected under Part 3 of the EPBC Act will be assessed by NOPSEMA.
- Duty holders will have clarity, certainty and consistency in their engagement with the sole Commonwealth regulator for petroleum activities, NOPSEMA.
- Duplication in environmental regulation will be reduced while maintaining strong environmental safeguards.

In relation to EPs, NOPSEMA must be reasonably satisfied that the EP meets the criteria for acceptance under s10A of the OPGGS Environment Regulations. The criteria for acceptance apply to the management of all impacts and risks including those matters protected under Part 3 of the EPBC Act.

The EPBC Approval was varied by the Variation to Conditions Attached to Approval for the Van Gogh Petroleum Field Development, North-West Shelf Project (EPBC 2007/3213) dated 18 September 2015.

A key element to the variation relates to streamlining of approvals, and conditions requiring an operational plan for managing impacts of the action. The requirement to submit a plan for the Minister's approval under Conditions 1, 2, 3 and 6 of the EPBC Approval 2007/3213 is "switched off" pursuant to Condition 14. Under Condition 14, a plan required by Condition 1, 2, 3 or 6 is automatically deemed to have been submitted to, and approved by, the Minister if the measures are included in an EP relating to the taking of the action that was submitted to NOPSEMA after 27 February 2014 and is in force under the OPGGS (E) Regs. Therefore Santos does not intend to separately submit a plan for the Minister's approval under Conditions 1, 2, 3 or 6 on the basis that the relevant measures are included in this NV EP (or, in the case of a decommissioning plan required by Condition 3, the relevant measure will be included in a Decommissioning EP that will be submitted at the appropriate time in the future).

The period of effect of the Van Gogh approval is currently until 31 December 2023. As at July 2020 Santos have liaised with DAWE (Post Approvals Section) and will be seeking an extension of time prior to the current expiry date. Conditions in relation to the EPBC Act approval that are considered relevant to the scope of this EP are provided in the table below.

It is noted that the Coniston and Novara approval notice (EPBC 2011/5995) grated on 15 October 2012 has an expiry date of 01 January 238 and does not require a plan (environment plan) for managing operational impacts of the action. It does however include conditions for an Oil Spill Contingency Plan (OSCP) and an Operational and Scientific Monitoring Plan which are addressed through the implementation of the OPEP and OSMP as outlined in the table below.

EPBC legislative control	Applicable to the environmental management of this activity
Van Gogh Ref. EPBC 2007/3213	
1. The person taking the action must submit, for the Minister's approval, a plan (or plans) for managing the offshore impacts of the action. The plan (or plans) must include measures for: **a) Offshore construction and installation**, including: (i) design and construction that considers the decommissioning of all structures and components above the sea floor; (ii) details of the anchor type and placements, methods for connection of mooring lines to the DTM buoy, installation of the risers and flowline paths; (iii) measures to minimise seabed disturbance; (iv) hydrotest fluid type, handling and disposal methods; (v) cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000; (vi) cetacean and whale shark sightings reporting; and (vii) measures for reporting environmental incidents. **b) Operations**, including: (i) tanker vetting procedures; (ii) produced formation water and naturally occurring radioactive materials (NORMs) monitoring and management; (iii) measures to reduce artificial lighting and noise associated with the development;	**No**. As noted above, Condition 14 (see below) switches off the requirement to submit a plan for the Minister's approval under this Condition 1 if the measures are included in an in-force EP approved by NOPSEMA. Accordingly, Santos does not intend to separately submit a plan for the Minister's approval under Condition 1 on the basis that the relevant measures are included in this NV EP. For ease of reference, the relevant sections of this NV EP that address those measures are: However, for ease of assessment, Santos provides the following references. **Condition 1a** – Not applicable. Construction and installation is not subject of this EP. **Condition 1b** – is addressed as outlined below. **(i)** **Section 2.9.1** (Offtake Operations). Provides details on tanker vetting procedures; **(ii)** **Section 2.8.10** (Waste Storage and Disposal). Provided details on produced formation water and naturally occurring radioactive materials (NORMs) monitoring and management;

EPBC legislative control	Applicable to the environmental management of this activity
(iv) cetacean interaction procedures for supply vessels and aircraft that are consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000; (v) cetacean and whale shark sightings reporting; and (vi) measures for reporting environmental incidents. The plan (or plans) for **offshore construction and installation** activities must be submitted at least one month prior to the commencement of these activities. The plan (or plans) for **operations** must be submitted at least two months prior to the commencement of these activities. Individual offshore activities may not commence until the plan (or plans) for that specific activity has been approved. The approved plan (or plans) must be implemented.	**(iii)** **Section 6.2** (Light Emissions). Provides details on measures to reduce artificial lighting and noise associated with the NV Operations; **(iv)** **Section 7.2** (Marine Fauna Interactions). Adopts a control consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 for supply vessels and aircraft.; **(v)** **Section 7.6.2** addresses fauna reporting in so far as it as a requirement of the Marine Fauna Interactions **(vi)** **Section 8.11** (Reporting and Notifications). Provides details on cetacean and whale shark sightings reporting and measures for reporting environmental incidents.
2. The person taking the action must submit for the Minister's approval an oil spill contingency plan to mitigate the environmental effects of any hydrocarbon spills. The oil spill contingency plan must be for the North West Shelf and Exmouth region and include: a) a description of resources available for use in containing and minimising impacts in the event of an oil spill and arrangements for accessing these; b) a demonstrated capacity to deploy oil spill response equipment within 12 hours of a spill occurring; c) training of staff in oil spill response measures and identifying roles and responsibilities of personnel during a spill response; d) identification of sensitive areas, in particular, Ningaloo Marine Park, and specific response measures for these areas; e) procedures for reporting oil spill incidents. The plan must be submitted at least one month prior to the commencement of **offshore construction and installation**. **Offshore construction and installation** may not commence until the plan is approved. The approved plan must be implemented.	**No**. As noted above, Condition 14 (see below) switches off the requirement to submit a plan for the Minister's approval under this Condition 2 if the measures are included in an in-force EP approved by NOPSEMA. Accordingly, Santos does not intend to separately submit a plan for the Minister's approval under Condition 2 on the basis that the relevant measures are included in this NV EP and OPEP. For ease of reference, the relevant sections of this NV OPEP that address those measures are: As detailed in **Section 8.9**, Santos will implement NV Operations OPEP (TV-00-RI-00003.02) in the event of a significant hydrocarbon spill. The following Sections address condition 2. a) Sections 9-20 of the OPEP describe the resources available to Santos for containing and minimising oil spill impacts. Sections 5.2, 7.2 and 9-20 detail the arrangements for accessing these resources. b) Section 9 – 12 summarises the mobilisation/deployment timeframes for oil spill equipment. Sections 5.5.3 and 5.5.4

EPBC legislative control	Applicable to the environmental management of this activity
	detail the testing undertaken to confirm mobilisation/deployment timeframes. c) Section 5.1 details the roles and responsibilities of personnel during a spill response. Sections 5.5.1 and 5.5.2 details the training requirements for oil spill response personnel. d) Sections 6.7 and 6.8 identify the key sensitive areas and protection priorities for spill response, including the Ningaloo Marine Park. Section 6.8 outlines the response measures selected for each protection priority area based on strategic Net Environmental Benefit Analysis. e) Procedures for reporting oil spill incidents are outlined within Section 7.1.
3. The person taking the action must submit **a decommissioning** plan (or plans) for approval by the Minister one year prior to **decommissioning** of the floating production, storage and offtake vessel, and three months prior to **decommissioning** any subsea wells, flowlines, or any associated infrastructure. The plan (or plans) must consider the complete removal of all structures and components above the sea floor. The approved plan must be implemented.	**No** – A separate EP will be prepared and submitted to NOPSEMA. It is noted that Santos will have in place a Decommissioning Plan no later than two years prior to the EOFL (Refer Table 8-2L. Section 2.15 (Decommissioning) and Section 8.8 (Asset Management) of the EP provide details on Santos decommissioning approach. In any event, Santos does not intend to separately submit a decommissioning plan to the Minister for approval under this Condition 3. Condition 14 (see below) switches off the requirement to submit a plan for the Minister's approval under this Condition 3 once our Decommissioning EP is submitted to and approved by NOPSEMA.
4. Between eight and twelve months after the commencement of offshore construction, the person taking the action must ensure that an independent audit of compliance with the conditions of approval is conducted. The independent auditor must be approved by the Minister. The audit criteria must be agreed by the Minister and the audit report must address the criteria to the satisfaction of the Minister.	**No** – the activity has commenced and is operational. An independent audit of compliance with the conditions of approval was conducted.
5. Note: Condition 5 was revoked on the date of this consolidated notice.	**N/A**
6. The person taking the action may choose to revise a management plan approved by the Minister under conditions 1 and 2 without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the	**No**. As noted above, Condition 14 (see below) switches off the requirement to submit a plan for the Minister's approval under this Condition 6 if the measures are included in an in-force EP approved by NOPSEMA.

EPBC legislative control	Applicable to the environmental management of this activity
revised plan would not be likely to have a new or increased impact. If the person taking the action makes this choice they must: (i) Notify the Department in writing that the approved plan has been revised and provide the Department with an electronic copy of the revised plan, (ii) Implement the revised plan form the date that the plan is submitted to the Department; and (iii) For the life of this approval, maintain a record of the reasons the person taking the action considers that taking the action in accordance with the revised plan would not be likely to have a new of increased risk or impact.	Accordingly, Santos does not intend to separately submit a revised management plan for the Minister's approval under Condition 6 on the basis that the relevant measures are included in this NV EP.
6A. The person taking the action may revoke their choice under condition 6 at any time by notice to the Department. If the person taking the action revokes the choice to implement a revised plan, without approval under section 143A of the Act, the plan approved by the Minister must be implemented.	**N/A**
6B. If the Minister gives a notice to the person taking the action that the Minister is satisfied that the taking of the action in accordance with the revised plan would be likely to have a new or increased impact, the: (i) Condition 6 does not apply or cases to apply, in relation to the revised plan; and (ii) The person taking the action must implement the plan approved by the Minister To avoid any doubt, this condition does not affect any operation of conditions 6 and 6A in the period before the day the notice is given. At the time of giving notice, the Minister may also notified that for a specified period of time that condition 6 does not apply for one or more specified plans required under the approval.	**N/A**
6C. Conditions 6, 6A and 6B are not intended to limit the operation of section 143A of the Act, which allows the person taking of the action to submit a revised management plan to the Minister for approval.	**N/A**
7. Note: Condition 7 was revoked on the date of this consolidated notice.	**N/A**
8. If, at any time after five years from the date of this approval, the Minister notifies the person taking the action in writing that the Minister is not satisfied that there has been substantial commencement of the development of the Van Gogh Petroleum	**No –** The Van Gogh Petroleum Field is in production.

EPBC legislative control	Applicable to the environmental management of this activity
Field, the development of the Van Gogh Petroleum Field must not thereafter be commenced.	
9. Within 3 months of the date of this notice, the person taking the action must arrange for a field test to be conducted to verify that the requirements of condition 2(b) (i.e. the capacity to deploy oil spill response equipment within 12 hours of a spill occurring) can be fulfilled. The test results must be provided to the Department within 14 days of the test being conducted. Note. The date stated in condition 9 relates to the date of the variation decision (3 May 2012),	**Yes –** Requirement was added by way of a variation on 3/5/2012 and are complied with.
10. Within 3 months of the date of this notice, the person taking the action must conduct an assessment to identify the following: a) any nonessential lighting on board the Floating Production, Storage and Offloading Vessel (FPSO); b) measures to minimise nonessential lighting on board the FPSO. The person taking the action must implement the measures identified in condition 10 b) Note. The date stated in condition 10 relates to the date of the variation decision (3 May 2012).	**Yes –** Requirement was added by way of a variation on 3/5/2012 and are complied with
11. Within 3 months of the date of this notice, the person taking the action must ensure that all staff on board the FPSO have undertaken the environmental induction training referred to in the Van Gogh Operations Environment Plan (Document no. TV-00-RI-004 Revision 1), Note. The date stated in condition 11 relates to the date of the variation decision (3 May 2012),	**Yes –** Requirement was added by way of a variation on 3/5/2012 and are complied with.
12. The person taking the action must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plans required by the approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries	**Yes –** Requirement was added by way of a variation on 3/5/2012 and are complied with.

EPBC legislative control	Applicable to the environmental management of this activity
of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	
13. Within 6 months of the date of this notice, the person taking the action must ensure that an independent audit of compliance with conditions 9, 10, 11 and 12 is conducted. The independent auditor and the audit criteria must be approved by the Minister at least 1 month before the audit and the audit report addressing the criteria must be submitted to the Minister within 2 months of the audit taking place. The audit report must be approved by the Minister. Note. The date stated in condition 13 relates to the date of the variation decision (3 May 2012).	**Yes –** Requirement was added by way of a variation on 3/5/2012 and are complied with
14. A plan required by condition 1, 2, 3 or 6 is automatically deemed to have been submitted to, and approved by, the Minister if the measures (as specified in the relevant condition) are included in an environment plan (or environment plans) relating to the taking of the action that: a) Was submitted to NOPSEMA after 27 February 2014; and b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations.	**Yes** - The NV EP was submitted to NOPSEMA in December 2014 and Accepted on 5 May 2015. Condition 14 will be invoked upon acceptance of this 5-year EP revision by NOPSEMA. i.e. the Plans (EP and OPEP) required by conditions, 1, 2 and 6 are automatically deemed to have been submitted to, and approved by, the Minister.
14A. Where a plan required by condition 1 or 2 has been approved by the Minister and the measures (as specified in the relevant condition) are included in an environment plan (or environment plans) that: a) Was submitted to NOPSEMA after 27 February 2014; and b) Either: i) Is in force under the OPGGS Environment Regulations; or ii) Has ended in accordance with regulation 25A of the OPGGS Environment Regulations. The plan approved by the Minister no longer needs to be implemented.	The implementation of this EP is considered to meet the requirements of this condition (i.e. any previous plan approved by the Minister no longer needs to be implemented).
14B Where an environment plan, which includes measures specified in the conditions referred to in conditions 14 and 14A above, is in force under the OPGGS Environment	**Yes –** Noted. Santos will comply with the EP as accepted by NOPSEMA.

EPBC legislative control	Applicable to the environmental management of this activity
Regulations that relates to the taking of the action, the person taking the action must comply with those measures as specified in that environment plan.	
Coniston Novara Ref. EPBC 2011/5995	
1. Within 30 days after the commencement of the action, the person taking the action must advise the department in writing of the actual date of commencement.	**No** – this condition is for a notification that must be made after commencement of the action. Notification was provided to DoEE (now DAWE) of the commencement of drilling in February 2013.
2. The person taking the action must maintain accurate records, substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plans, required by this approval, and make them available upon request to the department. Such records may be subject to audit by the department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the department's website. The results of audits may also be publicised through the general media.	**Yes** – this condition is a requirement for record keeping to be provided to DAWE demonstrates environmental management and evidence of compliance.
3. Within three months of every 12 month anniversary of the commencement of the action, the person taking the action must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the department at the same time as the compliance report is published.	**Yes** – this condition is compliance reporting provided to DAWE but is not considered to be a control measure for risks identified for the activity presented in this EP.
4. If the person taking the action wishes to carry out any activity otherwise than in accordance with the plans or programs as specified in the conditions, the person taking the action must submit to the department for the Minister's written approval a revised version of that plan or program. The varied activity shall not commence until the Minister has approved the varied plan or program in writing. The Minister will not approve a varied plan or program unless the revised plan or program would result in an equivalent or improved environmental outcome over time. If the Minister approves the revised plan or program, that plan or program must be implemented in place of the plan or program originally approved.	**Yes** – this condition stipulates a process whereby in the event that the nature of the activity presented in a plan or program specified by the conditions of approval, is to be carried out in a manner other than that detailed in that plan or program. The Plan or Programs required by conditions of this approval are an Oil spill contingency Plan (Condition 10), and an Operational and Scientific Monitoring Program (Condition 11).

EPBC legislative control	Applicable to the environmental management of this activity
5. If the Minister believes that it is necessary or convenient for the better protection of World Heritage properties (sections 12 & 15A), National Heritage places (sections 15B & 15C), Listed threatened species and communities (sections 18 & 18A), Listed migratory species (sections 20 & 20A) and/or Commonwealth marine areas (sections 23 & 24A), the Minister may request that the person taking the action make specified revisions to the plan or program specified in the conditions and submit the revised plan or program for the Minister's written approval. The person taking the action must comply with any such request. The revised approved plan or program must be implemented.	**Yes** – this condition stipulates a process to be followed, in the event that EP revisions to the management of the activity are required by the Federal Minister of the Environment and Energy but is not considered to be a control measure for risks identified for the activity as presented in this EP.
6. If, at any time after 5 years from the date of this approval, the person taking the action has not substantially commenced the action, then the person taking the action must not substantially commence the action without the written agreement of the Minister.	**No** – the activity has commenced and is operational
7. Unless otherwise agreed to in writing by the Minister, the person taking the action must publish all plans or programs referred to in these conditions of approval on their website. Each plan or program must be published on the website within one month of being approved. Note: The Minister may agree in writing to exclude the requirement to publish information that is considered confidential.	**Yes** – this condition stipulates a process by which the OPEP incorporating the Operational and Scientific Monitoring Program (OSMP) are to be publicised. However, publication is not considered to be a control measure for risks identified for the activity as presented in this EP.
8. The Exmouth Gulf must not be used by support vessels during the period 15 September to 31 October.	**No** – this condition refers only to the construction phase of the Coniston Novara development.
9. The person taking the action must implement cetacean and whale shark (*Rhincodon typus*) interaction procedures for support vessels and aircraft that are used to carry out the action, through all stages of the action from commencement. These procedures must be consistent with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 at a minimum and must include provision of cetacean sightings reports to the department.	**Yes** – vessel and aircraft movement are identified as risks that may result in potential environmental impacts associated with the activity and the condition has been applied as a control in managing the risk.
10. The person taking the action must develop and submit to the Minister for approval, an Oil Spill Contingency Plan that demonstrates the response preparedness of	**Yes** – a number of credible hydrocarbon spills to the marine environment have been identified for the activity and the existing approved operations

EPBC legislative control	Applicable to the environmental management of this activity
the person taking the action for any spills, including from offshore wells and infrastructure, pipelines, construction and operation vessels. This must include the capacity to respond to a spill and mitigate the environmental impacts on World and National heritage values, the Commonwealth marine area and species listed as threatened or migratory under the EPBC Act. The OPEP must include, but is not limited to: a) Identification of sensitive areas, species or habitats that may be impacted by a potential spill, as determined by site-specific modelling of worst-case scenario spills; b) Specific response measures for those sensitive areas, species or habitats and prioritisation of those areas during a spill response, including a net environmental benefit analysis of the response options; c) A description of resources available for use in containing and minimising impacts in the event of a spill and arrangements for accessing them; d) A demonstrated capacity to respond to a spill at the site. Identification of the response measures that can feasibly, and will, be applied within the first 48 hours of a spill occurring; e) Details of the insurance arrangements that have been made in respect of paying the costs associated with operational and scientific monitoring, as outlined in the OPEP and Operational and Scientific Monitoring Program required under Conditions 10 and 11, and repairing environmental damage arising from potential spills, as determined from the results of the Operational and Scientific Monitoring Program; f) Training of staff in spill response measures and identifying roles and responsibilities of personnel during a spill response; g) Procedures for reporting spill incidents to the department; and h) A demonstrated procedure for testing, maintenance and review of the OPEP. The OPEP must be submitted at least three months prior to the commencement of the action, or as otherwise agreed to in writing by the Minister. The person	NV Operations OPEP (TV-00-RI-00003.02) has been revised to include the content as listed by the condition.

EPBC legislative control	Applicable to the environmental management of this activity
taking the action must not commence the action until the OPEP is approved by the Minister. The approved OPEP must be implemented. Note: If a legal requirement is held by the proponent that requires submission of a plan that meets the above requirements, that plan may be submitted for the purpose of this condition.	
11. The person taking the action must develop and submit to the Minister for approval, an Operational and Scientific Monitoring Program that will be implemented in the event of a spill to determine the potential extent and ecosystem consequences of such a spill, including, but not limited to: a) Triggers for the initiation and termination of the Operational and Scientific Monitoring Program, including, but not limited to, spill volume, composition, extent, duration and detection of impacts; b) A description of the studies that will be undertaken to determine the operational response, potential extent of impacts, ecosystem consequences and potential environmental reparations required as a result of the spill; c) Details of the insurance arrangements that have been made in respect of the costs associated with operational and scientific monitoring and repairing any environmental damage arising from potential spills; d) Inclusion of sufficient baseline information on the biota and the environment that may be impacted by a potential spill, to enable an assessment of the impacts of such a spill. This must include sufficient information to determine the impact on the Whale shark population that feeds in the Ningaloo Marine World Heritage Area, including the reliance of this population of Whale sharks on coral spawning in the World Heritage Area as opposed to other food sources. e) A strategy to implement the scientific monitoring plan, including timelines for delivery of results and mechanisms for the timely peer review of studies; and f) Provision for periodic review of the program. The OSMP must be submitted at least three months prior to the commencement of the action, or as otherwise agreed in writing by the Minister. The person taking	**Yes** – monitoring activities to be implemented in the event of a spill during the activity have been incorporated into the NV Operations OPEP (TV-00-RI-00003.02); the OPEP includes the content as listed by the condition.

EPBC legislative control	Applicable to the environmental management of this activity
the action must not commence the action until the OSMP is approved by the Minister. The approved OSMP must be implemented. Note: If a legal requirement is held by the proponent that requires submission of a plan that meets the above requirements, that plan may be submitted for the purpose of this condition.	
12. In the event of a spill, the person taking the action must pay all costs associated with: a) All operational and scientific monitoring undertaken in response to the spill, as outlined in the OSMP approved by the Minister under Condition 11; b) Any environmental management and remediation and/or equivalent determined necessary by the results of the OSMP.	**No** – this condition stipulates a process by which spill response costs will be the responsibility of Santos and is not considered to be a control measure for risks identified for the activity as presented in this EP.
13. The development must be designed and constructed to allow for the complete removal of all structures and components above the seafloor during the decommissioning phase.	**No** – this condition refers only to the design and construction phase of the Coniston Novara development.
14. The person taking the action must submit a Decommissioning Plan to the Minister for approval at least twelve months prior to commencement of the decommissioning phase. Appropriate consideration must be given to matters of national environmental significance as defined by the EPBC Act and the net environmental benefit analysis of pursuing the proposed plan. Note: If a legal requirement held by the person taking the action requires submission of a plan that meets the above requirements, that plan may be submitted for the purpose of this condition.	**No** –a separate EP will be prepared and submitted for approval 12 months prior to the commencement of decommissioning.

Key Commonwealth Legislation and Regulations

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	This Act provides for the preservation and protection from injury or desecration areas and objects that are of significance to Aboriginal people, under which the Minister may make a declaration to protect such areas and objects. The Act also requires the discovery of Aboriginal remains to be reported to the Minister.	Commonwealth – Department of Environment and Energy	Yes, however there are no sites of Aboriginal heritage in the operational area	Section 3 (Environmental Description) Appendix D1
Australian Heritage Council Act 2003	This Act identifies areas of heritage value listed on the Register of the National Estate and sets up the Australian Heritage Council and its functions.	Australian Heritage Council	No. No heritage value listed site in the operational area	Section 3 (Environmental Description) Appendix D1
Australian Marine Orders	Marine Orders (MO) are subordinate rules made pursuant to the Navigation Act 2012 and Protection of the Sea (Prevention of Pollution from Ships) Act 1983 affecting the maritime industry. They are a means of implementing Australia's international maritime obligations by giving effect to international conventions in Australian law.	Yes	AMSA	Vessel movements, safety, discharges and emissions
Australian Maritime Safety Authority Act 1990 (AMSA Act)	This Act specifies that the Australian Maritime Safety Authority's (AMSA) role includes protection of the marine environment from pollution from ships and other environmental damage caused by shipping. AMSA is responsible for administering the Marine Orders in Commonwealth waters. Facilitates international cooperation and mutual assistance in preparing and responding to a major oil spill incident and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies. Requirements are given effect through AMSA.	AMSA	Yes, Act established AMSA. AMSA is responsible for administering the Marine Orders in Commonwealth	Section 6.2 (light emission) Section 6.5 (Planned operations discharge) Section 6.3 (Atmospheric Emissions)

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	AMSA is the lead agency for responding to oil spills in the marine environment and is responsible for the Australian National Plan for Maritime Environmental			Section 6.5 (Interaction with other users) Section 7.2 (Discharge of non-hazardous solid waste) Section 7.4 (Discharge of hazardous materials (solids and liquids) Section 7.9 (Surface release of MDO) Section 7.10 (Surface release of HFO)
Biosecurity Act 2015 *Biosecurity Regulations 2016* *Australian Ballast Water Management Requirements (Version 7)*	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.	Commonwealth – Department of Agriculture and Water Resources	Yes. Provisions within the Act relating to the management of ballast water and biofouling are of relevance to the activities.	Section 7.1 (Introduction of IMS)

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	Australian Ballast Water Management Requirements (Version 7) July 2017 – document provides requirements for management measures to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ship's ballast water.			
Conservation and Land Management Act 1984	DBCA is responsible for the day to day management of marine parks vested with Marine Parks and Reserves Authority (MPRA) and provide administrative support to the MPRA. Marine nature reserves, marine parks and marine management areas are the three reserve categories vested in the MPRA. Offshore operations must comply with specific marine park conditions when navigating or conducting activities in or near areas designated as marine sanctuaries for conservation, recreational, ecological, historical, research, educational, or aesthetic qualities.	Department of Biodiversity, Conservation and Attractions (DBCA)	Yes, EMBA encompasses Marine Parks	Sections 7.6 to 7.10
Environment Protection and Biodiversity Conservation Act 1999 *Environment Protection and Biodiversity Conservation Amendment Regulations 2006*	A new streamlined approach for offshore petroleum and GHG activity environmental approvals came into effect on 28 February 2014. The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is now the sole assessor for offshore petroleum activities in Commonwealth waters. Under the new arrangements, environmental protection will be met through NOPSEMA's decision-making processes. Where activities have existing approvals under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), these will continue to apply.	Commonwealth – Department of Environment and Energy	Yes. EPBC approval and associated conditions apply to the activity (EPBC 2007/3213). See Section 1.8	Section 1.8 (Legislative Framework)
Environment Protection and Biodiversity Conservation Act 1999 - Proclamation – Ningaloo Marine Park (Commonwealth	The Declaration of Ningaloo Marine Park in Commonwealth Waters	Commonwealth – Department of Environment and Energy	Yes. Ningaloo Marine Park is within the EMBA	Sections 7.6 to 7.10

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
Waters)				
Environmental Protection (Unauthorised Discharges) Regulations 2004	The purpose of the Regulations is to cover discharges into the environment from business or commercial activity which are not serious enough to cause pollution or environmental harm and breach the provisions of the Environmental Protection Act 1986 (EP Act).	Department of Water and Environment Regulation	Yes	Section 6.5 (Planned Operations Discharge) Section 6.7 (PW disposal) Section 7.2 (Discharge of non-hazardous solid waste) Section 7.4 (Discharge of hazardous materials (solids and liquids)
Underwater Cultural Heritage Act 2018	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.	Commonwealth – Department of Environment and Energy	Yes, however no shipwrecks within the operational area	Section 3 (Environmental Description) Sections 7.6 to 7.10
Maritime Powers Act 2013	Protects the heritage values of shipwrecks and relics for shipwrecks over 75 years. It is an offence to interfere with a shipwreck covered by this Act. Available historic shipwreck locations covered by international conventions enacted by this legislation have been identified and assessed (as applicable) within this EP.	The Department of Immigration and Border Protection	Yes, however no shipwrecks within the operational area	Section 3 (Environmental Description) Sections 7.6 to 7.10

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
Native Title Act 1993	Recognising by Australian law that some Indigenous people have rights and interests to their land that come from their traditional laws and customs.	Commonwealth – Department of Environment and Energy	No, There are no Native Title claims in the vicinity of the operational area	Section 3 (Environmental Description) Sections 7.6 to 7.10
National Greenhouse and Energy Reporting Act 2007	Introduces a single national reporting framework for the reporting and dissemination of information about GHG emissions, GHG projects and energy use and production of corporations.	Commonwealth – Department of Environment and Energy And Climate Change Authority	Yes. GHG emissions required to be reported	Section 8.11.1 (Recording of Discharges / Emissions to the Environment)
Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007	This Act implements the requirements of MARPOL 73/78 Annex VI for shipping in Commonwealth waters.	Commonwealth, Department of Infrastructure and Regional Development.	Yes	Section 6.3 (Atmospheric Emissions)
Navigation Act 2012	The Act replaces the century old Navigation Act 1912 with a contemporary legislative framework for maritime regulation. The Act reflects changes in the maritime sector and is the primary legislative means for the Australian Government to regulate international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters. It also gives effect to the relevant international conventions to which Australia is a signatory, including MARPOL (enacted under Marine Orders). A number of Marine Orders apply directly to offshore petroleum exploration and production activities:	AMSA (operational) Department of Infrastructure and Regional Development Minister for Infrastructure and Regional Development	Yes	Section 6.2 (light emission) Section 6.5 (Interaction with other users) Sections 7.6 to 7.10

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	+ Marine Order21: Safety and emergency arrangements + Marine Order 30: Prevention of collisions + Marine Order 41 – Carriage of Dangerous Goods + Marine Order - 57: Helicopter Operations + Marine Order - 59: Off-shore industry vessel operations + Marine Order - 60: Floating Offshore facilities + Marine Order 70 – Seafarer Certification			
Offshore Petroleum and Greenhouse Gas Storage Act 2006 *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*	Petroleum exploration and development activities in Australia's offshore areas are subject to the environmental requirements specified in the OPGGS Act and associated Regulations. The OPGGS Act contains a broad requirement for titleholders to operate in accordance with "good oil-field practice". Specific environmental provisions relating to work practices essentially require operators to control and prevent the escape of wastes and petroleum. The Act also requires that activities are carried out in a manner that does not unduly interfere with other rights or interests, including the conservation of the resources of the sea and sea-bed, such as fishing or shipping. In some cases, where there are particular environmental sensitivities or multiple use issues it may be necessary to apply special conditions to an exploration permit area. The holder of a petroleum title must maintain adequate insurance against expenses or liabilities arising from activities in the title, including expenses relating to clean-up or other remedying of the effects of the escape of petroleum.	NOPSEMA	Yes	This EP. See Section 1.8.2

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	The OPGGS (E) Regulations 2009 provide an objective based regime for the management of environmental performance for Australian offshore petroleum exploration and production activities in areas of Commonwealth jurisdiction. Key objectives of the Environment Regulations include: + to ensure operations are carried out in a way that is consistent with the principles of ecologically sustainable development; + to adopt best practice to achieve agreed environment protection standards in industry operations; and + to encourage industry to continuously improve its environmental performance.			
Offshore Petroleum and Greenhouse Gas Storage (Environment) Amendment (Financial Assurance) Regulations 2014	Requirement for titleholders to maintain sufficient financial assurance to meet the costs, expenses and liabilities that may arise in connection with carrying out petroleum activities among other things.	NOPSEMA	Yes, Financial Assurance maintained	N/A
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989	Regulates the manufacture, importation and use of ODS (typically used in fire-fighting equipment and refrigerants). Applicable to the handling of any ODS.	Commonwealth - Department of Environment and Energy	Yes	Section 6.3 (Atmospheric Emissions)
Protection of the Sea (Powers of Intervention) Act 1981 *Protection of the Sea (Powers of Intervention) Regulations 1983*	The Act authorises the Commonwealth to take measures for the purpose of protecting the sea from pollution by oil and other noxious substances discharged from ships and provides legal immunity for persons acting under an AMSA direction.	Commonwealth – Department of Infrastructure and Regional Development (AMSA administers the	Yes	Section 6.5 (Planned Operations Discharge) Section 6.7 (PW disposal)

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
		act and is responsible for ensuring compliance)		Section 7.2 (Discharge of non-hazardous solid waste) Section 7.4 (Discharge of hazardous materials (solids and liquids) Sections 7.6 to 7.10
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994*	The Act is administered by AMSA and deals with the protection of the marine environment from ship-sourced pollution 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 following Marine Orders relating to marine pollution prevention have been put in place to give effect to relevant regulations of Annexes I, II, III, IV, V and VI of MARPOL 73/78: + Marine Orders - Part 91: Marine Pollution Prevention - Oil + Marine Orders - Part 93: Marine Pollution Prevention - Noxious Liquid Substances + Marine Orders - Part 94: Marine Pollution Prevention - Harmful Substances in Packaged Forms	Commonwealth – Department of Infrastructure and Regional Development (AMSA administers the act and is responsible for ensuring compliance)	Yes	Section 6.3 (Atmospheric Emissions) Section 6.5 (Planned Operations Discharge) Section 7.2 (Discharge of non-hazardous solid waste) Section 7.4 (Discharge of hazardous materials (solids and liquids) Section 7.9 (Surface release of MDO)

Commonwealth Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	+ Marine Orders - Part 95: Marine Pollution Prevention – Garbage + Marine Orders - Part 96: Marine Pollution Prevention – Sewage + Marine Orders - Part 97: Marine Pollution Prevention - Air Pollution + Marine Orders - Part 98: Marine Pollution - Anti-fouling Systems			Section 7.10 (Surface release of HFO)
Protection of the Sea (Civil Liability of Bunker Oil Pollution Damage) Act 2008	This Act implements the requirements for the International Convention on Civil Liability for Bunker Oil Pollution Damage.	AMSA	Yes	Section 7.9 (Surface release of MDO)
Protection of the Sea (Harmful Antifouling Systems) Act 2006	This Act relates to the protection of the sea from the effects of harmful anti-fouling systems. It prohibits the use of harmful organotins in ant-fouling paints used on ships.	Commonwealth, Department of Infrastructure and Regional Development and AMSA	Yes, although the act does not directly relate to IMS risk, rather the harmful effect of anti-fouling systems.	Section 7.1 (Introduction of IMS)

State Legislation

State Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
Biodiversity Conservation Act 2016	The Biodiversity Conservation Act 2016 came into effect on 3 December 2016 and replaced the Wildlife Conservation Act 1950. Relating to potential impacts to listed species: this Act provides for the conservation and protection of Western Australian wildlife.	Department of Parks and Wildlife (DPAW)	Yes, hydrocarbon spill scenarios impacts relating to potential impacts to listed species	Section 7.6 to 7.10
Conservation and Land Management Act 1984	DBCA is responsible for the day to day management of marine parks vested with Marine Parks and Reserves Authority (MPRA) and provide administrative support to the MPRA. Marine nature reserves, marine parks and marine management areas are the three reserve categories vested in the MPRA. Offshore operations must comply with specific marine park conditions when navigating or conducting activities in or near areas designated as marine sanctuaries for conservation, recreational, ecological, historical, research, educational, or aesthetic qualities.	Department of Biodiversity, Conservation and Attractions (DBCA)	Unplanned hydrocarbon/chemical release	Section 7.6 to 7.10
Dangerous Goods Safety Act 2004	Act relating to the safe storage, handling and transport of dangerous goods and for related purposes	Department of Mines, Industrial Safety and Regulation	Yes, however WA waters are outside of the operational area.	N/A
Environmental Protection Act 1986	Relating to non-routine operations (potential oil spills) in areas under State jurisdiction: this Act provides for the prevention, control and abatement of pollution and environmental harm and for the conservation, preservation, protection, enhancement and management of the environment.	Environmental Protection Authority	Yes, environment may receive exposure from a hydrocarbon spill	Section 7.6 to 7.10

State Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
Fish Resources Management Act 1994 *Fish Resources Management Regulations 1995.*	This Act establishes a framework for management of fishery resources and is the nominated lead agency responsible for implementing Western Australian marine biosecurity management requirements through implementation of the Fish Resources Management Act 1994 (FRMA 1994) and associated regulations. Under regulation 176 of the Fish Resources Management Regulations 1995 (FRMR), it is an offence to translocate live non-endemic fish to WA without permission. Under section 105 of the Fish Resources Management Act 1994 (FRMA), it is an offence to bring noxious fish into WA. Also, under Part 16A of the FRMA, the Department has emergency powers to deal with incursions of IMS, which include directing a person to carry out necessary activities to prevent or control the spread of IMS, or to eradicate them in WA waters. If these activities are not undertaken, department may carry out the activities and recover any costs incurred from the person initially directed	DPIRD	Yes. Vessels required to comply with the Act.	Section 7.1 (Introduction of IMS)
National Greenhouse and Energy Reporting Act 2007	Introduces a single national reporting framework for the reporting and dissemination of information about GHG emissions, GHG projects and energy use and production of corporations.	Commonwealth – Department of Environment and Energy, and Climate Change Authority	Yes. GHG emissions required to be reported	Section 8 (Recording of Discharges / Emissions to the Environment)
West Australian Maritime Archaeology Act 1973	Protects maritime archaeological sites on state land and in State waters, such as bays, harbours and rivers. Other than shipwrecks, it includes single relics, such as an anchor, and land sites associated with exploration, early	West Australian Museum	Yes. maritime archaeological site in the operational area. Sites may receive	Section 7.6 to 7.10

State Legislation / Regulations	Summary	Administering Authority	Relevant to activity?	EP Sections
	settlements, whaling and pearling camps and shipwreck survivor camps		exposure from a hydrocarbon spill.	
Western Australia Marine Act 1982	Relating to vessel movements: an Act to regulate navigation and shipping.	Department of Transport	No, WA waters are outside of the operational area	N/A

International Agreements and Conventions

International Agreements and Conventions	Summary	Relevant to Activity	EP Section
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 the Japan Australia Migratory Bird Agreement or JAMBA)	This agreement recognises the special international concern for the protection of migratory birds and birds in danger of extinction that migrate between Australia and Japan. Implemented in EPBC Act 1999.	Only relevant in so far as the credible spill scenario may result in impact to migratory seabirds foraging in area.	Section 7.5 to 7.9
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 the China Australia Migratory Bird Agreement or CAMBA)	This agreement recognises the special international concern for the protection of migratory birds and birds in danger of extinction that migrate between Australia and China. Implemented in EPBC Act 1999.	Only relevant in so far as the credible spill scenario may result in impact to migratory seabirds foraging in area.	Section 7.5 to 7.9
Convention for the Control of Transboundary Movements of Hazardous Wastes and Their Disposal 1989 (Basel Convention)	This convention deals with the transboundary movement of hazardous wastes, particularly by sea. Implemented in *Hazardous Waste (Regulation of Exports and Imports) Act 1989.*	Activity does not involve transboundary movement of hazardous wastes.	N/A
United Nations Convention on Biological Diversity -1992	An international treaty to sustain life on earth.	Relevant only insofar as the activity may interact with MNES (threatened and migratory species) protected under the EPBC Act.	All Sections
Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC 90)	This convention comprises national arrangements for responding to oil pollution incidents from ships, offshore oil facilities, sea ports and oil handling. The convention	In the event that worse-case credible spill scenarios may enact a national arrangement for response.	Section 7.5 to 7.9

International Agreements and Conventions	Summary	Relevant to Activity	EP Section
	recognises that in the event of pollution incident, prompt and effective action is essential.		
Convention on the Conservation of Migratory Species of Wild Animals 1979 (Bonn Convention)	The Bonn Convention aims to improve the status of all threatened migratory species through national action and international agreements between range states of particular groups of species.	Only relevant in so far as the credible spill scenario may result in impact to MNES protected migratory species.	Section 7.5 to 7.9
International Convention for the Establishment of an International Fund for Compensation for Oil Pollution Damage (Fund 92)	The Civil Liability Convention ensures that adequate compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships by placing liability for such damage on the owner of the ship.	Relevant to oil tankers, not supply or support vessels. Offtake tanker compliance for this is outside of the EP scope.	N/A
International Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL 73/78)	This Convention and Protocol (together known as MARPOL 73/78) build on earlier conventions in the same area. MARPOL is concerned with operational discharges of pollutants from ships. It contains five Annexes, dealing respectively with oil, noxious liquid substances, harmful packaged substances, sewage and garbage. Detailed rules are laid out as to the extent to which (if at all) such substances can be released in different sea areas. The legislation giving effect to MARPOL in Australia is the Protection of the Sea (Prevention of Pollution from Ships) Act 1983, the Navigation Act 1912 and several Parts of Marine Orders made under this legislation.	Through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*	N/A
International Convention for the Safety of Life at Sea 1974	This convention is generally regarded as the most important of all international treaties concerning the safety of merchant ships Implemented in the *Air Navigation Act 1920.*	Only relevant in so far as SOLAS relates to safety aspects of the activity, such as navigation aids which reduce potential for vessel collision and hydrocarbon release to the environment.	Section 6.5 – Interaction with other marine users

International Agreements and Conventions	Summary	Relevant to Activity	EP Section
International Convention on Civil Liability for oil pollution damage (1969)	This convention provides a mechanism for ensuring the payment of compensation for oil pollution damage.	Relevant to oil tankers. Outside scope of EP.	N/A
International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention) 2004	The IMO has been addressing the problem of IMS in ship's ballast water since the 1980s. Ballast water and sediments guidelines were adopted in 1991 and the ballast water convention was adopted in 2004. Recent accession by Finland has triggered the final entry into force of these international requirements. As a result, the International Convention for the Control and Management of Ships Ballast Water and Sediment will enter into force on 8th September 2017 (IMO Briefing 22 2016). It aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments. Ballast Water Management systems must be approved by the Administration in accordance with this IMO Guidelines.	Potential internationally sourced vessel operating in Australian Waters which could have the potential for introduction of Invasive Marine Species and potential ballast water exchange	Section 7.1 – Introduction of IMS
United Nations Convention on the Law of the Sea (UNCLOS) (1982)	Part XII of the convention sets up a general legal framework for marine environment protection. The convention imposes obligations on State Parties to prevent, reduce and control marine pollution from the various major pollution sources, including pollution from land, from the atmosphere, from vessels and from dumping (Articles 207 to 212). Subsequent articles provide a regime for the enforcement of national marine pollution laws in the many different situations that can arise. Australia signed the agreement relating to the implementation of Part XI of the Convention in 1982, and UNCLOS in 1994.	Only relevant to the extent that Santos will comply with MARPOL through the following relevant Marine Orders relating to marine pollution prevention have been put in place to give effect to relevant regulations of Annexes I, II, III, IV, V and VI of MARPOL 73/78: + Marine Orders - Part 91: Marine Pollution Prevention - Oil	Section 6.5 – Operational discharges Section 7.1 – Introduction of IMS

International Agreements and Conventions	Summary	Relevant to Activity	EP Section
		+ Marine Orders Part 93: Marine Pollution Prevention - Noxious Liquid Substances + Marine OrderPart 95: Marine Pollution Prevention – Garbage + Marine Order Part 96: Marine Pollution Prevention – Sewage + Marine Order Part 97: Marine Pollution Prevention - Air Pollution + Marine Order Part 98: Marine Pollution - Anti-fouling Systems	
United Nations Framework Convention on Climate Change (1992)	The objective of the convention is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system. Australia ratified the convention in December 1992 and it came into force on 21 December 1993.	Only relevant into the extent that to reduce impact of GHG emissions associated with vessel use, Santos will comply with MARPOL Annex VI (Marine Orders Part 97: Marine Pollution Prevention – Air Pollution) and require the use of low sulphur fuel.	Section 6.3 – Atmospheric emissions
Vienna Convention for the Protection of the Ozone Layer 1985 and the Montreal Protocol on Substances that Deplete the Ozone Layer 1987	The Vienna Convention is a multilateral environmental agreement that acts as framework for international efforts to protect the ozone layer. The accompanying Montreal Protocol specifies the reduction goals for the uses of chlorofluorocarbons (CFCs), the main chemical agents causing ozone depletion.	Safe disposal and use of ODS.	Section 6.3 - Atmospheric emissions

Appendix C. Crude Oil Properties

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Crude Assay Job Number 2019-PTAD-000374

13-June-2019

Van Gogh-Coniston-Novara Crude Blend

17.0 °API

1.75 mgKOH/g TAN

0.372 %wt Sulphur

on behalf of

Santos WA Energy Ltd

List of Revisions

Rev No	Date	Details of Revision	Issued by
0	13-Jun-19	Final Report Issued	Michelle Fernandez Laboratory Manager

Van Gogh-Coniston-Novara Crude Blend Assay Job Number 2019-PTAD-000374

Date: June 13, 2019

Santos WA Energy Ltd
PO Box 5624, St Georges Tce
Perth WA 6831
Australia

For the Attention of	:	Raymond Klein
Sample(s) received from	:	FPSO Ningaloo Vision
Sample(s) drawn on	:	06 April 2019
Samples received on	:	04 May 2019
Sample(s) submitted as	:	2 x 20L containers of Van Gogh-Coniston-Novara Crude Blend from FPSO Ningaloo Vision
Additional Samples	:	1x1L Bottle for RVP testing 2 x 30ml VOA Vials
Seals on Sample(s)	:	None

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Van Gogh-Coniston-Novara Crude Blend
Report ID : 2019-PTAD-000374

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ASSAY SLATE SUMMARY

Report ID	2019-PTAD-000374			Cut Range						
Crude ID	Van Gogh-Coniston-Novara Crude Blend									
Client ID	Santos WA Energy Ltd									
Date	13 June 2019									
Test	Method	Unit	Whole Crude	IBP - 230°C	IBP - 260°C	230 - 360°C	260 - 360°C	360 - 540°C	Residue 360°C+	Residue 540°C+
Fractional Distillation	ASTM D2892	%mass		1.5	5.3	30.5	26.7	44.2	68.0	23.8
		%volume		1.7	5.9	32.0	27.8	43.7	66.3	22.6
Density @15°C		kg/L	0.9523	0.8738	0.8875	0.9124	0.9153	0.9631	0.9770	1.0050
Specific Gravity @60/60°F	ASTM D4052 / D70	-	0.9529	0.8742	0.8880	0.9129	0.9159	0.9637	0.9776	1.0060
API Gravity		°API	17.0	30.4	27.8	23.5	23.0	15.3	13.2	9.2
Aniline Point	ASTM D611	°C		54.50	57.50	60.40	60.50	65.40	66.20	
Aniline Gravity Product	Calc	-		3955	3767	3307	3220	2291	1995	
Arsenic	ICPMS	wt ppb	42							
Ash	ASTM D482	%mass	0.018						0.021	
Asphaltenes	IP143	%mass	<0.5						<0.5	
Carbon Content	ASTM D5291	%mass	86.82							
Hydrogen Content	ASTM D5291	%mass	11.79							
Carbon Residue - Micro	ASTM D4530	%mass	2.45						3.81	
Cetane Index - Procedure A	ASTM D4737	-				34.4	35.8			
Cetane Index - Procedure B	ASTM D4737	-				32.2	33.8			
Characterization Factor,calc	UOP 375	-	11.3	11.2	11.2	11.1	11.1	11.5	11.6	11.8
Cloud Point	ASTM D2500	°C				<-42	<-42			
Colour ASTM	ASTM D6045	-				<0.5	<0.5			
Copper Corrosion	ASTM D130	-		1a	1a	1a	1a			
Distillation	ASTM D86	-				see page 14	see page 14			
FIA - Aromatic	ASTM D1319	%volume		<5.0 (2.6)	<5.0 (3.0)					
Flash Point	ASTM D93	°C	134.0	74.0	87.0					
Freeze Point	ASTM D2386	°C		<-60.0	<-60.0					
Heat of Combustion - Gross,calc	ASTM D4868	MJ/kg	43.67	45.18	44.97	44.55	44.50		43.64	
Heat of Combustion - Net,calc	ASTM D4868	MJ/kg	41.18	42.46	42.29	41.96	41.91		41.21	
Hydrogen Sulphide	UOP 163	wt ppm	<1.0							
Kinematic Viscosity @-20°C	ASTM D445	cSt		10.17	18.30					
Kinematic Viscosity @20°C	ASTM D445	cSt		3.235	4.507					
Kinematic Viscosity @40°C	ASTM D445	cSt		2.180	2.876	7.835	9.409			
Kinematic Viscosity @70°C	ASTM D445	cSt	31.21			3.571	4.056	43.22	189.7	
Kinematic Viscosity @100°C	ASTM D445	cSt	10.95					13.07	40.53	1130.0
Kinematic Viscosity @135°C	ASTM D445	cSt								134.7
Mercury Content (Note1)	UOP938	wt ppb	<1.00							
Metal - Nickel	ASTM D7691	wt ppm	1						1	7
Metal - Vanadium		wt ppm	<1						<1	1
Metal - Sodium		wt ppm	<1						<1	<1
Metal - Iron		wt ppm	1						2	3
Metal - Copper		wt ppm	<1						<1	<1
Metal - Calcium		wt ppm	6							
Metal - Potassium		wt ppm	1							
Metal - Zinc		wt ppm	1							
Naphthalenes	ASTM D1840	%volume		0.05	0.07					
Nitrogen - Basic	UOP269	wt ppm	643					561	1085	
Nitrogen - Total	ASTM D4629/D5762	wt ppm	2130	<0.3	0.4	34	40	1468	2953	4219
Pour Point - Upper	ASTM D5853	°C	-15							
Pour Point	ASTM D97	°C				<-42	<-42	+3	+18	+66
Reid Vapour Pressure(Note 2)	ASTM D323	kPa	15.0							
Salt Content	ASTM D3230	lb/1000bbl	10.7							
Sediment by Extraction	ASTM D473	%mass	0.13							
Smoke Point	ASTM D1322	mm		15.2	14.0					
Sulphur - Mercaptan	UOP163	wt ppm	390	58	94	357	394			
Sulphur - Total	D4294/D5453	%mass	0.372	0.0659	0.0560	0.126	0.138	0.327	0.468	0.730
Total Acid Number	ASTM D664	mg KOH/g	1.75	<0.10	<0.10	0.20	0.30	1.89	2.14	
Water by Distillation	ASTM D4006	%volume	0.300							
Benzene	GCMS	mg/L	<0.1							
Toluene		mg/L	<0.1							
Ethylbenzene		mg/L	<0.1							
Xylenes		mg/L	<0.1							
Wax Content	UOP46	%mass	<5.0							

NOTES:

(1) Arsenic & Mercury analysis was performed on a separate VOA vial. Tests was performed at Intertek-Sydney laboratory, report No. 3441017

(2) RVP was tested on a separate 1L bottle

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Properties of Whole Crude

			Whole Crude
Report ID	2019-PTAD-000374		
Crude ID	Van Gogh-Coniston-Novara Crude Blend		
Client ID	Santos WA Energy Ltd		
Sample Number:	2019-PTAD-000374-001		
Date	13 June 2019		
Test	Method	Unit	
Density @15°C	ASTM D5002	kg/L	0.9523
Specific Gravity @60/60°F		-	0.9529
API Gravity		°API	17.0
Arsenic	ICPMS	wt ppb	42.0
Ash	ASTMD482	%mass	0.018
Asphaltenes	IP 143	%mass	<0.5
Carbon Residue - Micro	ASTM D4530	%mass	2.45
Carbon Content	ASTM D5291	%mass	86.82
Hydrogen Content			11.79
Characterization Factor,calc	UOP 375	-	11.3
Flash Point	ASTM D93	°C	134.00
Heat of Combustion - Gross,calc	ASTM D4868	MJ/kg	43.67
Heat of Combustion - Net,calc			41.18
Kinematic Viscosity @70°C	ASTM D445	cSt	31.21
Kinematic Viscosity @100°C	ASTM D445	cSt	10.95
Mercury (Note 1)	UOP 938	µg/kg	<1.00
Metal - Nickel	ASTM D7691	wt ppm	1
Metal - Vanadium			<1
Metal - Sodium			<1
Metal - Iron			1
Metal - Copper			<1
Metal - Calcium			6
Metal - Potassium			1
Metal - Zinc			1
Nitrogen - Basic	UOP269	wt ppm	643
Nitrogen - Total	ASTM D4629	wt ppm	2130
Pour Point - Upper	ASTM D5853	°C	-15
Reid Vapour Presure (Note 2)	ASTM D323	kPa	15.00
Salt Content	ASTM D3230	PTB	10.7
Sediment by Extraction	ASTM D473	%mass	0.13
Sulphur - Mercaptan	UOP163	wt ppm	390
Hydrogen Sulphide	UOP163	wt ppm	<1.0
Sulphur - Total	ASTM D4294	mg/kg	0.372
Total Acid Number	ASTM D664	mg KOH/g	1.75
Water by Distillation	ASTM D4006	%volume	0.300
Benzene	GCMS	mg/L	<0.1
Toluene		mg/L	<0.1
Ethylbenzene		mg/L	<0.1
Xylenes		mg/L	<0.1
Wax Content	UOP46	%mass	<5.0

NOTES:

(1) Mercury analysis performed on a separate VOA vial.

(2) RVP was tested on a separate 1L bottle .

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DISTILLATION OVERVIEW

Crude ID:		Van Gogh-Coniston-Novara Cr		TBP Data _ ASTM D2892 & D5236					
Report ID:		2019-PTAD-000374							
Sample Number:		2019-PTAD-000374-001							
Temp °C	**% mass**	**Cumulative % mass**	**Density (kg/L)**	**SG 60/60°F**	**API Gravity**	**%volume**	**Cum. % volume**	**Mid %vol**	**Cum. Mid. %vol**
230	1.5	1.5	0.8738	0.8742	30.4	1.7	1.7	0.9	0.9
260	3.8	5.3	0.8931	0.8936	26.8	4.2	5.9	2.1	3.0
280	4.8	10.1	0.9000	0.9005	25.6	5.1	11.0	2.6	5.5
310	8.7	18.8	0.9113	0.9118	23.7	9.1	20.1	4.6	10.1
330	5.1	23.9	0.9167	0.9172	22.8	5.3	25.4	2.7	12.7
360	8.1	32.0	0.9279	0.9284	20.9	8.3	33.7	4.2	16.9
420	13.0	45.0	0.9532	0.9537	16.9	13.0	46.7	6.5	23.4
450	11.2	56.2	0.9607	0.9613	15.7	11.1	57.8	5.6	28.9
480	8.8	65.0	0.9681	0.9687	14.6	8.7	66.6	4.4	33.3
510	7.3	72.3	0.9725	0.9758	13.5	7.1	73.7	3.6	36.8
540	3.9	76.2	0.9752	0.9758	13.5	3.8	77.4	1.9	38.7
540+	23.8	100.0	1.0049	1.0055	9.2	22.6	100.0	11.3	50.0
360+	68.0	100.0	0.9770	0.9776	13.2	66.3	100.0	33.2	50.0

SIMDIS DATA - ASTM D7900 /D7169

temp °C	mass%	temp °C	mass%	temp °C	mass%
104.4	0.5	353.0	34	469.0	68
196.2	1	356.0	35	473.8	69
218.0	2	359.2	36	478.6	70
228.6	3	362.4	37	483.8	71
237.0	4	365.6	38	488.8	72
243.4	5	368.8	39	494.2	73
250.0	6	372.0	40	499.6	74
255.8	7	375.2	41	505.2	75
261.0	8	378.6	42	511.0	76
266.2	9	381.8	43	517.0	77
271.2	10	385.2	44	523.4	78
276.0	11	388.6	45	529.6	79
280.6	12	392.0	46	536.2	80
285.0	13	395.2	47	543.2	81
289.0	14	398.6	48	550.4	82
292.8	15	402.0	49	558.0	83
296.2	16	405.4	50	565.6	84
299.8	17	408.6	51	573.6	85
303.2	18	411.8	52	582.2	86
306.4	19	415.2	53	590.8	87
309.4	20	418.4	54	599.8	88
312.6	21	421.4	55	609.6	89
315.8	22	424.6	56	619.6	90
318.8	23	427.6	57	630.4	91
321.8	24	431.0	58	641.8	92
324.8	25	434.2	59	654.0	93
328.0	26	437.4	60	670.6	94
331.0	27	440.8	61	693.2	95
334.0	28	444.2	62	707.6	96
337.2	29	447.8	63	719.6	97
340.4	30	451.8	64		98
343.8	31	455.8	65		99
346.8	32	460.0	66		99.5
349.8	33	464.4	67		

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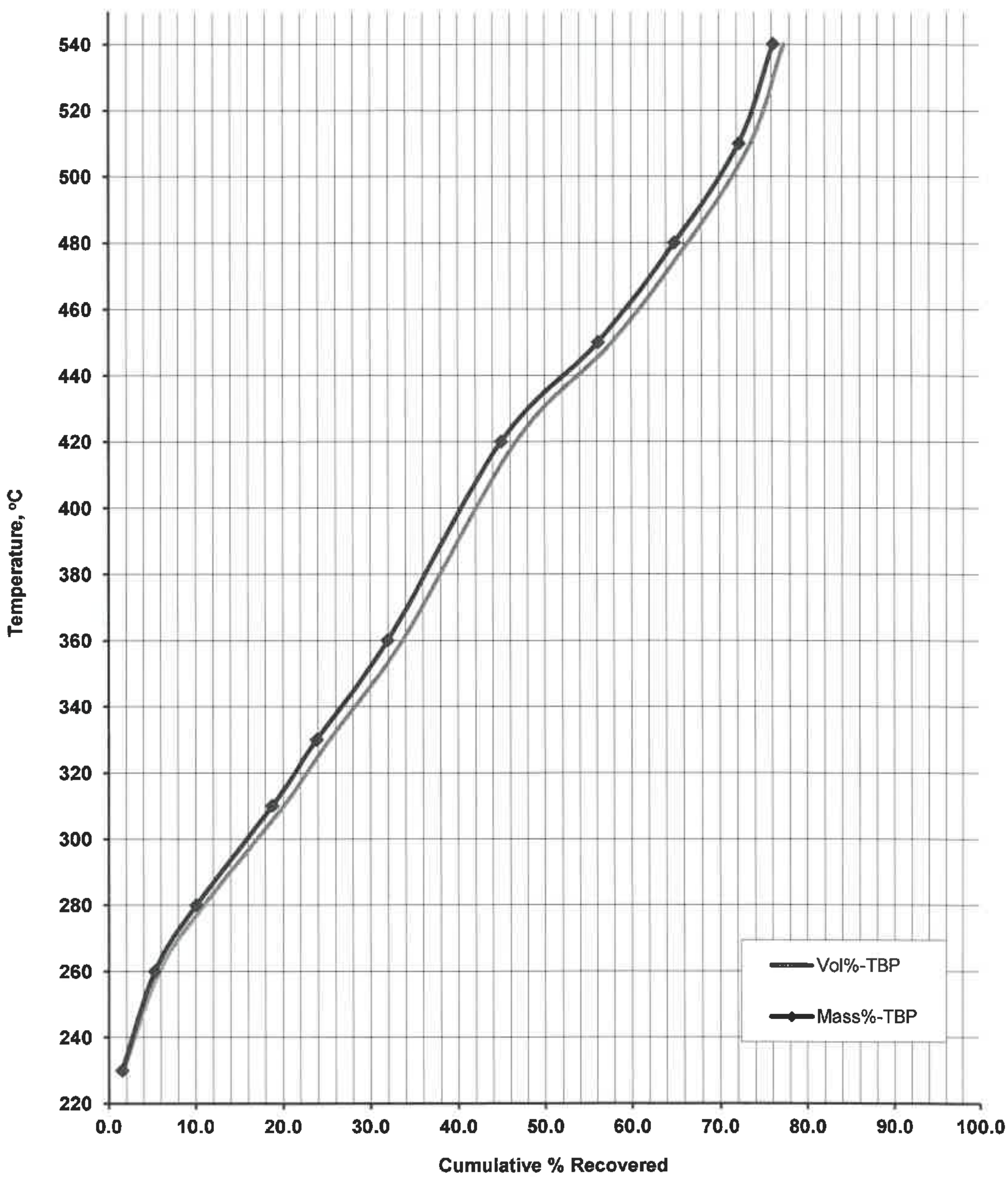
TRUE BOILING POINT CURVE

Van Gogh-Coniston-Novara Crude Blend

2019-PTAD-000374



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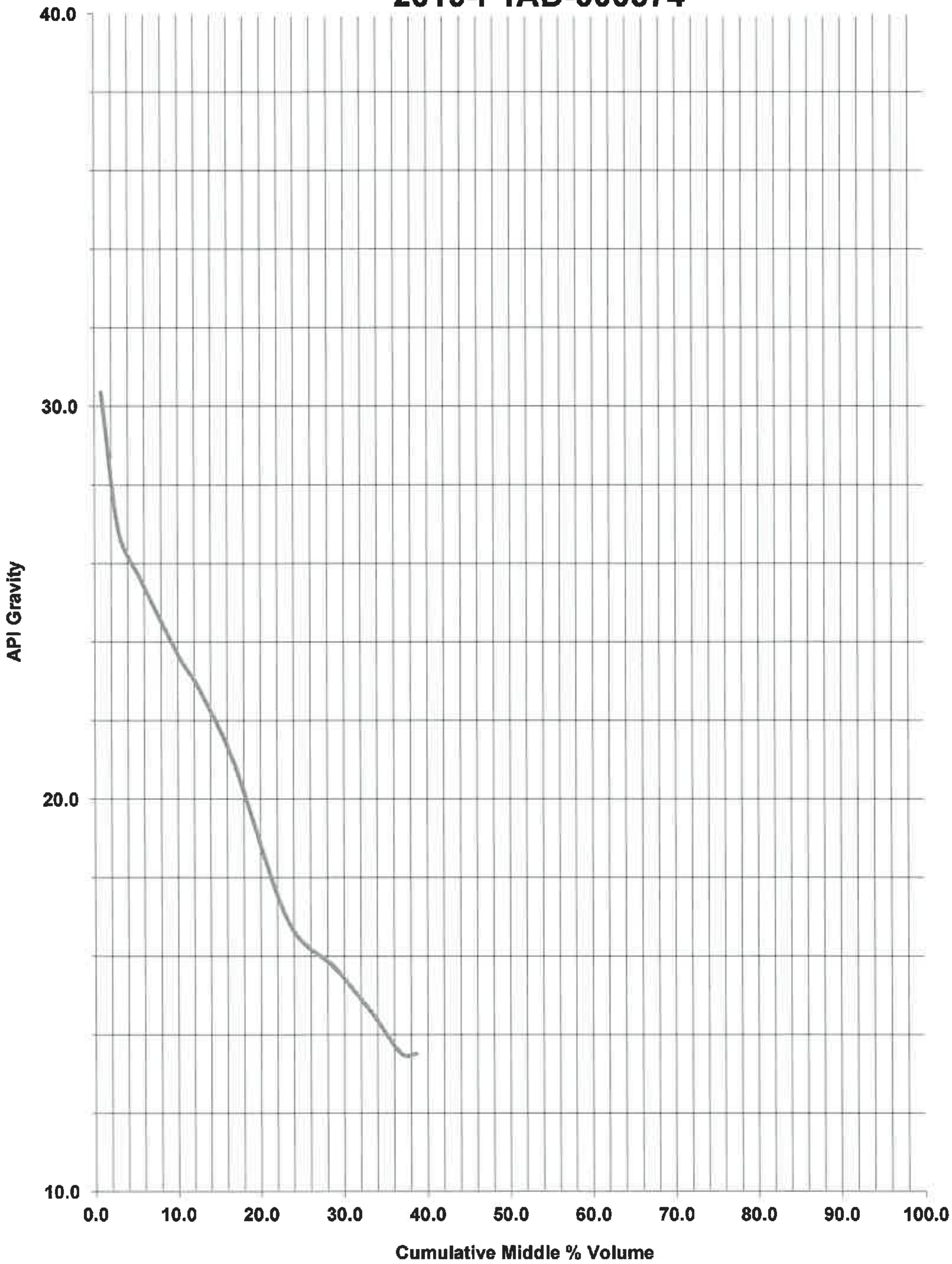
Graph of API vs Mid Volume
Van Gogh-Coniston-Novara Crude Blend
2019-PTAD-000374



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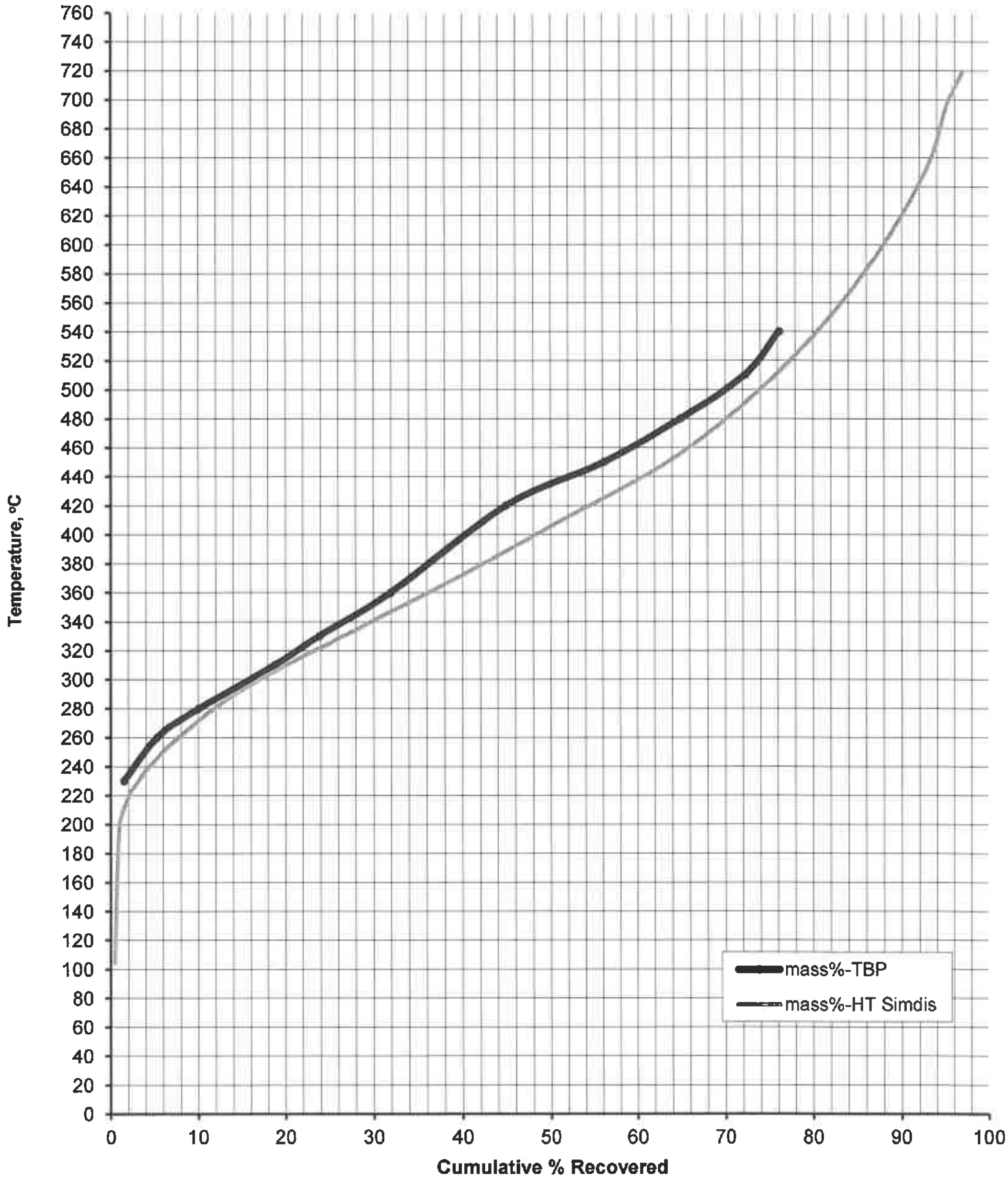
Graph of True Boiling Point vs Simdis
Van Gogh-Coniston-Novara Crude Blend
2019-PTAD-000374



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Properties of Kerosene

Report ID	2019-PTAD-000374		Kerosene	
Crude ID	Van Gogh-Coniston-Novara Crude Blend			
Client ID	Santos WA Energy Ltd		IBP - 230°C	IBP - 260°C
Date	13 June 2019			
Test	Method	Unit		
Fractional Distillation	ASTM D2892	mass%	1.5	5.3
		vol%	1.7	5.9
Density @15°C	ASTM D4052	kg/L	0.8738	0.8875
Specific Gravity @60/60°F		-	0.8742	0.8880
API Gravity		°API	30.4	27.8
Aniline Point	ASTM D611	°C	54.50	57.50
Aniline Gravity Product	Calc	-	3955	3767
Characterization Factor,calc	UOP 375	-	11.2	11.2
Copper Corrosion	ASTM D130	-	1a	1a
FIA - Aromatic	ASTM D1319	%volume	<5.0 (2.6)	<5.0 (3.0)
Flash Point	ASTM D93	°C	74.0	87.0
Freeze Point	ASTM D2386	°C	<-60.0	<-60.0
Heat of Combustion - Gross,calc	ASTM D4868	MJ/kg	45.18	44.97
Heat of Combustion - Net,calc	ASTM D4868	MJ/kg	42.46	42.29
Kinematic Viscosity @-20°C	ASTM D445	cSt	10.17	18.30
Kinematic Viscosity @20°C	ASTM D445	cSt	3.235	4.507
Kinematic Viscosity @40°C	ASTM D445	cSt	2.180	2.876
Naphthalenes	ASTM D1840	%volume	0.05	0.07
Nitrogen - Total	ASTM D4629	wt ppm	<0.3	0.4
Smoke Point	ASTM D1322	mm	15.2	14.0
Sulphur - Mercaptan	UOP163	wt ppm	58	94
Sulphur - Total	IP336	%mass	0.0659	0.0560
Total Acid Number	ASTM D664	mg KOH/g	<0.10	<0.10

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Total Quality. Assured.

Properties of Gas Oil

Report ID	2019-PTAD-000374		Gas Oil	
Crude ID	Van Gogh-Coniston-Novara Crude Blend			
Client ID	Santos WA Energy Ltd		230 - 360°C	260 - 360°C
Date	13 June 2019			
Test	Method	Unit		
Fractional Distillation	ASTM D2892	mass%	30.5	26.7
		vol%	32.0	27.8
Density @15°C	ASTM D4052	kg/L	0.9124	0.9153
Specific Gravity @60/60°F		-	0.9129	0.9159
API Gravity		°API	23.5	23.0
Aniline Point	ASTM D611	°C	60.40	60.50
Aniline Gravity Product	Calc	-	3307	3220
Cetane Index - Procedure A	ASTM D4737	-	34.4	35.8
Cetane Index - Procedure B	ASTM D4737	-	32.2	33.8
Characterization Factor,calc	UOP 375	-	11.1	11.1
Cloud Point	ASTM D2500	°C	<-42	<-42
Colour ASTM	ASTM D6045	-	<0.5	<0.5
Copper Corrosion	ASTM D130	-	1a	1a
Distillation	ASTM D86	-	see page 14	see page 14
Heat of Combustion - Gross,calc	ASTM D4868	MJ/kg	44.55	44.50
Heat of Combustion - Net,calc	ASTM D4868	MJ/kg	41.96	41.91
Kinematic Viscosity @40°C	ASTM D445	cSt	7.835	9.409
Kinematic Viscosity @70°C	ASTM D445	cSt	3.571	4.056
Nitrogen - Total	ASTM D4629	wt ppm	34	40
Pour Point	ASTM D97	°C	<-42	<-42
Sulphur - Mercaptan	UOP163 /ASTM D32	wt ppm	357	394
Sulphur - Total	IP336	%mass	0.126	0.138
Total Acid Number	ASTM D664	mg KOH/g	0.20	0.30

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Properties of Vacuum Gas Oil

Report ID	2019-PTAD-000374		VGO
Crude ID	Van Gogh-Coniston-Novara Crude Blend		
Client ID	Santos WA Energy Ltd		360 - 540°C
Date	13 June 2019		
Test	Method	Unit	
Fractional Distillation	ASTM D2892/ D5236	mass%	44.2
		vol%	43.7
Density @15°C	ASTM D4052	kg/L	0.9631
Specific Gravity @60/60°F		-	0.9637
API Gravity		°API	15.3
Aniline Point	ASTM D611	°C	65.40
Aniline Gravity Product	Calc	-	2291
Characterization Factor,calc	UOP 375	-	11.5
Kinematic Viscosity @70°C	ASTM D445	cSt	43.22
Kinematic Viscosity @100°C	ASTM D445	cSt	13.07
Nitrogen - Basic	UOP269	wt ppm	561
Nitrogen - Total	ASTM D5762	wt ppm	1468
Pour Point	ASTM D97	°C	+3
Sulphur - Total	IP336	%mass	0.327
Total Acid Number	ASTM D664	mg KOH/g	1.89

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Total Quality. Assured.

Properties of Residue

			Residue	Residue
Report ID	2019-PTAD-000374			
Crude ID	Van Gogh-Coniston-Novara Crude Blend			
Client ID	Santos WA Energy Ltd			
Date	13 June 2019			
Test	Method	Unit	360°C+	540°C+
Fractional Distillation	ASTM D2892/D5236	mass%	68.0	23.8
		vol%	66.3	22.6
Density @15°C	ASTM D4052	kg/L	0.9770	1.0050
Specific Gravity @60/60°F		-	0.9776	1.0060
API Gravity		°API	13.2	9.2
Aniline Point	ASTM D611	°C	66.20	-
Aniline Gravity Product	Calc	-	1995	-
Ash	ASTM D482	%mass	0.021	-
Asphaltenes	IP143	%mass	<0.5	-
Carbon Residue - Micro	ASTM D4530	%mass	3.81	-
Characterization Factor,calc	UOP 375	-	11.6	11.8
Heat of Combustion - Gross,calc	ASTM D4868	MJ/kg	43.64	-
Heat of Combustion - Net,calc	ASTM D4868	MJ/kg	41.21	-
Kinematic Viscosity @70°C	ASTM D445	cSt	189.7	-
Kinematic Viscosity @100°C	ASTM D445	cSt	40.53	1130.0
Kinematic Viscosity @135°C	ASTM D445	cSt	-	134.7
Metal - Nickel	ASTM D7691	wt ppm	1	7
Metal - Vanadium		wt ppm	<1	1
Metal - Sodium		wt ppm	<1	<1
Metal - Iron		wt ppm	2	3
Metal - Copper		wt ppm	<1	<1
Nitrogen - Basic	UOP269	wt ppm	1085	-
Nitrogen - Total	ASTM D5762	wt ppm	2953	4219
Pour Point	ASTM D97	°C	+18	+66
Sulphur - Total	IP336	%mass	0.468	0.730
Total Acid Number	ASTM D664	mg KOH/g	2.14	-

#REF!

Van Gogh-Coniston-Novara Crude Blend Assay Job Number 2019-PTAD-000374

ASTM 86 - DISTILLATION DATA

Sample Descriptions / Label : Van Gogh-Coniston-Novara Crude Blend

Boiling range	° C	Fractions	
		230	**260**
		360	**360**
Yield	Wt. %	30.5	26.7
	Vol.%	32.0	27.8
Initial boiling point	° C	255.0	281.5
5% recovered	° C	272.7	291.2
10% recovered	° C	277.2	293.5
20% recovered	° C	282.2	296.4
30% recovered	° C	287.8	299.4
40% recovered	° C	293.8	303.1
50% recovered	° C	299.6	307.0
60% recovered	° C	306.4	311.3
70% recovered	° C	312.8	316.1
80% recovered	° C	319.7	322.0
90% recovered	° C	327.6	328.9
95% recovered	° C	332.7	334.1
Final Boiling Point	° C	336.3	337.4
Volume recovered	% Vol.	98.3	98.3
Residue	% Vol.	1.3	1.3
Loss	% Vol.	0.4	0.4

Appendix D1 – Description of the Existing Environment

Appendix D1: Description of the Existing Environment

Two separate PMST searches were completed to inform this EP. One for the operational area and one for the EMBA. Section 3.1.1 of the EP describes how the EMBA is derived and how it informs the information contained in Section 3 of the EP and within Appendix D1.

The two outputs of the DoAWE Protected Matters Search Tool (PMST), are provided as Appendix D2 and Appendix D3.

The searches are completed using the exact coordinates that are utilised to produce the figures throughout Section 3 of the EP, ensuring that the EMBA encompasses the full range of environmental receptors that might be contacted by surface and subsurface hydrocarbons at the low exposure level in the highly unlikely event of a worst case oil spill.

On the first page of the PMST report, is a coarse graphic showing the area over which the search has been conducted. However, the granularity of this can make the output look different to the spatial area represented on figures within the EP.

The co-ordinates are also provided within the PMST report to allow for duplication of the search and verification if required.

Santos do not have control over the PMST search tool output, but instead have provided the reports and coordinates to ensure transparency.

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1. Introduction

This document describes the existing environment that may be contacted (EMBA) by petroleum activities associated with this EP, and includes details of the particular relevant values and sensitivities of that environment as required by the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and State Western Australian Petroleum (Submerged Lands) (Environment) Regulations 2012.

Desktop searches of the operational area, PW mixing zone and the EMBA were undertaken in January 2020 using the DoAWE (previously DoEE) Protected Matters Search Tool for the purpose of identifying matters of national environmental significance listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). This document is informed by this search as well as published scientific literature and studies where applicable. Descriptions of all fauna are provided, with a focus on protected species that are threatened and migratory.

1.1 Geographical Extent

The geographical extent of this document is aligned with the EMBA as described in Section 3.1 of the NV Operations EP.

Where relevant, the physical, biological and social environments within the operational area, PW mixing zone and EMBA are discussed with reference to the IMCRA Provincial Bioregions. **Figure 1-1** presents the provinces in relation to the operational area and EMBA, noting that the PW mixing zone is in close proximity to the operational area. The bioregion relevant to the operational area and PW mixing zone is the North-west Marine Region. The operational area and PW mixing zone lie within the Northwest Province of this region.

The North-west Marine Region and South-west Marine Region are relevant to the wider EMBA. Provinces of relevance within these bioregions are detailed below:

North-west Marine Region:

+ Northwest Shelf Transition;
+ Timor Province;
+ Northwest Transition;
+ Northwest Province;
+ Northwest Shelf Province;
+ Central Western Transition;
+ Central Western Shelf Transition; and
+ Central Western Shelf Province.

South-west Marine Region:

+ Central Western Province;
+ Southwest Shelf Transition;
+ Southwest Transition; and
+ Southwest Shelf Province.

The extent of the EMBA as presented **Figure 1-1** also encompasses Indonesian waters and the Christmas Island Province.

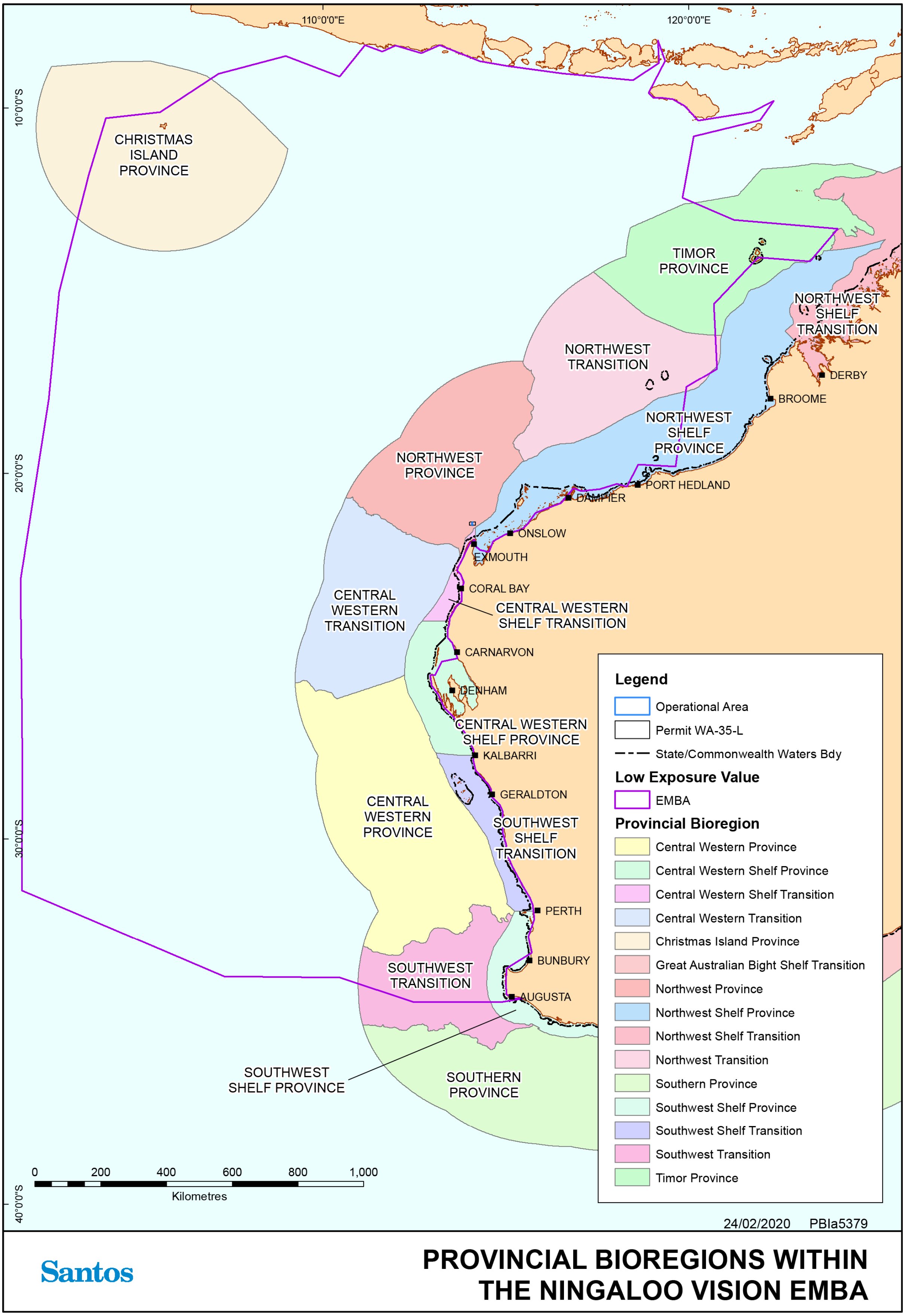


Figure 1-1: IMCRA 4.0 Provincial Bioregions within the EMBA and in relation to the NV Operations

2. Physical Environment

2.1 Geomorphology

2.1.1 Formation History

Approximately 550–160 million years ago, the EMBA formed part of the northern margin of Gondwana. About 300 million years ago, crustal stretching, rifting and breakup-initiated development of an extensive basin that became the site for deposition of sediments (Baker *et al*. 2008 in DEWHA 2008). Approximately 135 million years ago the continent broke up resulting in the separation of greater India and Australia. Ocean spreading associated with the continental break-up resulted in the creation of the Argo and Cuvier abyssal plains. Subsidence of the rifted margin resulted in the formation of the Exmouth and Scott plateaux and the Rowley Terrace. The narrow shelf south of North West Cape was formed approximately 130 million years ago as a result of the separation of India and seafloor spreading (Baker *et al*. 2008 in DEWHA 2008).

The South-west region has been relatively stable throughout its recent geological past. This has shaped a continental shelf that has high wave exposure and is punctuated with coastal features such as island groups and fringing coastal reefs providing sheltered habitats for marine communities (2008a).

2.1.2 Present Day Geological Features

The EMBA consists of four major landform features: continental shelf, continental slope, continental rise and abyssal plain. The majority of the area consists of either continental shelf or continental slope (DEWHA 2008).

Limited surveys have shown that the continental slope in the EMBA comprises diverse geological features such as canyons, plateaux, terraces, ridges, reefs, banks and shoals (Source: DEWHA (2008). These features are significant in that over half of the total area of banks and shoals across Australia's entire marine jurisdiction occurs in the Commonwealth waters from the South Australian border to the Northern Territory border, as well as 39% of terraces and 56% of deeps, holes and valleys (DEWHA 2008).

An important characteristic of the EMBA is the significant narrowing of the continental shelf around North West Cape from the broad continental shelf in the north (**Figure 2-2**). For example, in the Joseph Bonaparte Gulf (at the Northern Territory boundary), the continental shelf is around 400 km wide, whereas at North West Cape the shelf is only 7 km wide – the narrowest of anywhere on the Australian continental margin (DEWHA 2008). Shelf width affects oceanography with flow on effects to productivity and ecosystem functioning.

The continental shelf north of Cape Leveque is characterised by a rimmed ramp where the waters over the outer margins of the shelf (approximately 50 to 100 m waters depth) are shallower than the middle portions (up to 150 m water depth). The rim at its outer edge is the site of a number of coral reefs including Ashmore, Cartier, Scott and Seringapatam (DEWHA 2008).

The Indonesian archipelago lies between the Pacific and Indian oceans, and bridges the continents of Asia and Australia. The archipelago is divided into several shallow shelves and deep-sea basins.

2.1.3 Sediments

2.1.3.1 Operational Area

Within the operational area, soft sediment is the dominant habitat. A survey of seabed habitat has previously been conducted at the Coniston/Novara fields (RPS, 2011a) and at the Van Gogh Field (Apache, 2009). The seabed survey at the Coniston/Novara fields, along the flowlines and production manifold locations, has revealed a flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (including anemones, sea stars, soft corals, crabs, shrimp and sea urchins) and an infaunal community dominated by polychaetes and crustaceans. This survey found no unique communities or communities of particular regional significance (RPS, 2011a). Similarly, a seabed survey at the Van Gogh field has revealed a flat substrate comprising mud and silts sediments with sparse epifauna (including sponges, echinoderms and crustaceans) and an infaunal community comprising mainly polychaetes and crustaceans (Apache, 2009).

Within the larger PW mixing zone, the benthic habitat is expected to be similar to that within the operational area comprising predominantly soft sediments with a sparse epi-benthic community. The depth of the operational area and PW mixing zone (>300 m) precludes the existence of benthic primary producers (i.e. photosynthetic organisms including hard corals, seagrasses and macroalgae), which are typical of shallower coastal areas, as seabed light availability at these depths is insufficient to support photosynthesis.

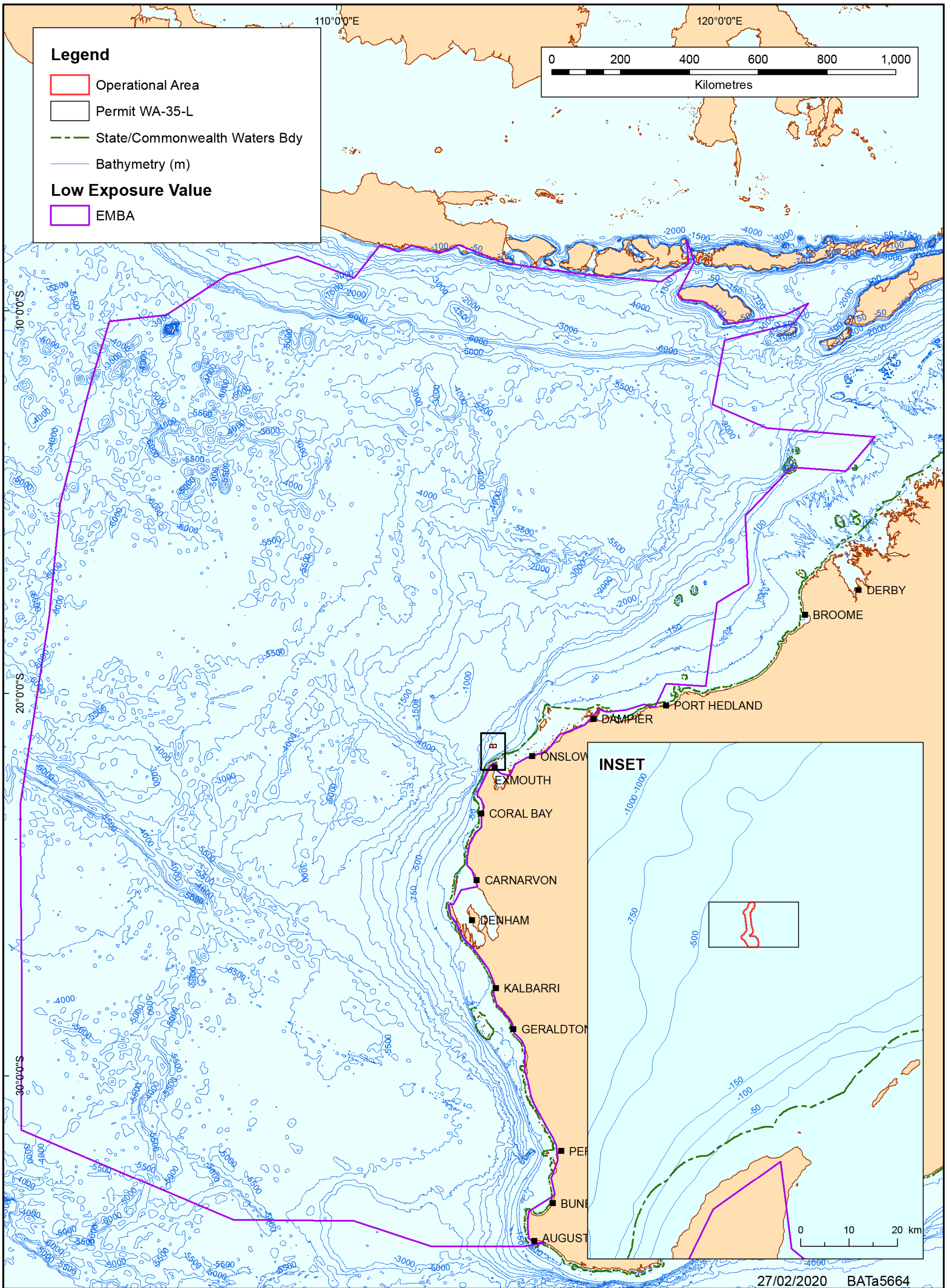
2.1.3.2 EMBA

The distribution and resuspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic events such as cyclones. Further offshore, on the mid to outer shelf and on the slope itself, sediment movement is primarily influenced by ocean currents and internal tides. Internal tides describe the tidal movement across a slope of water stratified by marked differences in density. Internal tides cause resuspension and net down-slope deposition of sediments on the North West Shelf (DEWHA 2008).

Surveys conducted over the North West Shelf indicate that similar sediments occur extensively over this geographic region, but with spatial variation in the grain size and origin of the surface sediments.

The ecology of the southwest is also greatly influenced by the lack of river discharge into the Region. The few significant rivers adjacent to the Region flow intermittently and their overall discharge is low. The low discharge of rivers and the generally low rate of biological productivity also results in low turbidity (suspended sediments), making the waters of the Region relatively clear (McLoughlin & Young 1985). Surface sediments in the area are predominantly composed of skeletal remains of marine fauna, with lenses of weathered sands (McLoughlin & Young 1985).

Several geomorphic formations have been associated with Key Ecological Features (DEWHA 2008) and these are discussed in **Section 10**.



Santos BATHYMETRY WITHIN THE NINGALOO VISION EMBA

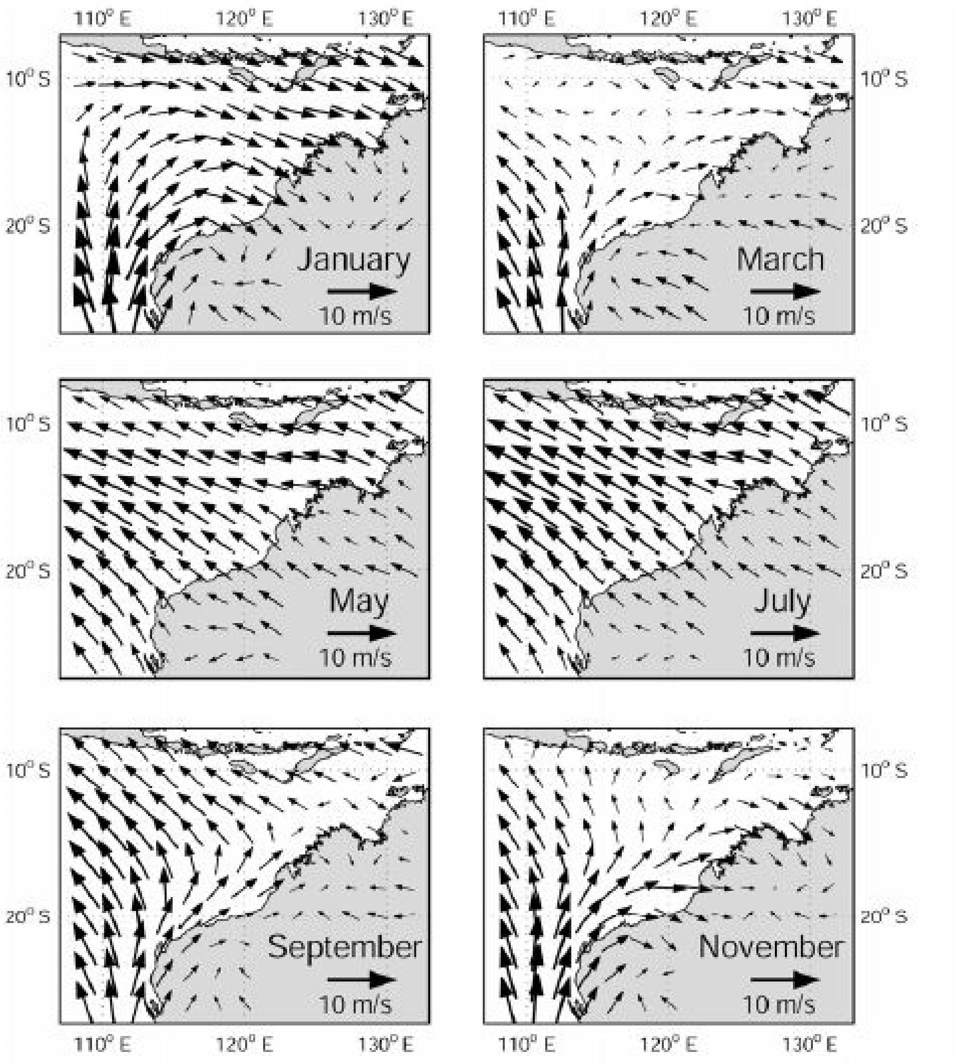
Figure 2-1: Bathymetry of EMBA

2.2 Climate

Waters in the northern extent of the EMBA predominantly lie in the arid tropics, experiencing high summer temperatures and periodic tropical cyclones in summer. Rainfall in the region is low, although intense rainfall may occur during the passage of summer tropical cyclones and thunderstorms (Condie *et al*. 2006). Mean air temperatures range from a minimum of 11°C in winter to a maximum of 36°C in summer (Condie *et al*. 2006). Due to the arid climate, daytime visibility in the area is generally greater than 5 nautical miles (SSE 1991).

The summer and winter seasons fall into the periods September–March and May–July, respectively. Winters are characterised by clear skies, fine weather, predominantly strong east to southeast winds and infrequent rain (calculated from NCEP-NCAR dataset measured from 1982 to1999; Condie *et al*. (2006); **Figure 2-3**).

Summer winds are more variable, with strong south-westerlies dominating. Transitional wind periods, during which either pattern may predominate, can be experienced in April–May and September of each year.



Calculated from NCEP-NCAR dataset measured from 1982 to 1999. Source: Condie *et al*. (2006)

Figure 2-2: Seasonally averaged winds at 10 m above mean sea level

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Tropical cyclones generate the most significant storm conditions in the area (SSE 1993). These clockwise-spiralling storms have generated wind speeds 50–120 knots (SSE 1991). Tropical cyclones develop in the eastern Indian Ocean, and the Timor and Arafura Seas during the summer months. Three to four cyclones per year are typical, with the official cyclone season being November through to April (BoM 2013). In Indonesia, the main variable in climate is not temperature or pressure, but rainfall, which varies greatly by month and place, ranging from 997 millimetres (mm) to 4,927 mm.

The South West bioregion experiences a Mediterranean style climate that is characterised by cool, wet winters and hot, dry summers. In winter, wind patterns are characterised by a prevailing westerly wind stream. This enables winter cold fronts and strong westerly winds to regularly penetrate the south-west, with cold fronts crossing the coast every week or so. Apart from the passage of storms, typically lasting one day or less, the weather is otherwise mild in winter with winds variable and relatively weak. In summer, cold fronts rarely penetrate into the south of the state with any strength and hot easterly winds prevail.

2.3 Oceanography

Major drivers of marine ecosystems include ocean currents, tides, waves, temperature and salinity. The dominant offshore sea surface current is the Leeuwin Current (**Figure 2-4**), which carries warm tropical water south along the edge of Western Australia's continental shelf, reaching its peak strength in winter and becoming weaker and more variable in summer (Condie *et al*. 2006). The current is typically located seaward of the shelf break (200 m isobath) and is a narrow, surface current, extending to a depth of 150 m (BHPB 2005, Woodside 2005) and a width of 50–100 km (DEWHA 2008). The formation of meanders and eddies are also a feature of the Leeuwin Current and a number of eddies occur south of Shark Bay (DEWHA 2008). The strength of the Leeuwin Current is influenced by seasonal variability in the pressure gradient (DEWHA 2008). The Holloway Current is the prevailing seasonal current, travelling south-west along the north West Australian coast in winter and north-east in summer (Brewer et al. 2007).

The nearshore Ningaloo Current flows northwards opposite to the Leeuwin Current, along the outside of the Ningaloo Reef and across the inner shelf from September to mid-April, (BHPB 2005, Woodside 2005). The Indonesian Throughflow is the other important current influencing the upper 200 m of the outer North West Shelf (Woodside 2005). This current brings warm and relatively fresh water to the region from the western Pacific via the Indonesian Archipelago (**Figure 2-4**). Modelling undertaken by Woodside and CSIRO Marine and Atmospheric Research indicates that significant east–west flows occur across the North West Shelf to the north of the North West Cape, possibly linking water masses in the area (Woodside 2005, Condie *et al*. 2006).

Sea surface currents over the NWS are generated by several components, including tidal-forcing, local wind-forcing and residual drift. Tidal and wind-forcing are the dominant contributions to local sea surface currents. The orientation and degree of drop off of the continental shelf slope influences the oceanography of the area. The tides of the NWS have a strong semi-diurnal signal with four tide changes per day (Holloway and Nye 1985). Peak tidal flows are from the north-northwest on the ebb, and to the south-southeast on the flood (Holloway and Nye 1985; SSE 1993). Measurements of tidal currents mid shelf are predicted to attain average speeds of approximately 0.25 knots during neap tides and up to 0.5 knots during spring tides (NSR 1995; WNI 1995).

The dominant sea surface offshore current (typically seaward of the 200 m isobath) is the Leeuwin Current, which carries warm tropical water south along the edge of WA's continental shelf, reaching its peak strength in winter and becoming weaker and more variable in summer. The current is described as a surface current, extending in depth to 150 m (BHPB 2005; Woodside 2005). Closer to the coast, the Ningaloo Current flows in a northerly direction, in the opposite direction to the Leeuwin Current, along the outside of the Ningaloo Reef and across the inner shelf from September to mid-April (BHPB 2005; Woodside 2005). The Indonesian Throughflow is the other important current influencing the upper 200 m of the outer NWS (Woodside 2005). This current brings warm and relatively fresh water to the region from the western Pacific via the Indonesian Archipelago. Modelling undertaken by Woodside indicates that significant east-west flows across the NWS to the north of the North West Cape, possibly linking water masses in the area (Woodside 2005).

The wave climate in the northwest is composed of locally-generated wind waves (seas) and swells that are propagated from distant areas (WNI 1995). In summer the seas typically approach from the west and southwest, while in winter the seas typically approach from the south and east. Mean sea wave heights are typically less than 1 m and peak heights of less than 2 m are experienced in all months of the year (WNI 1995).

Indonesian waters, especially the eastern part of the archipelago, play an important role in the global water mass transport system, in which warm water at the surface conveys heat to the deeper cold water in what is known as the great ocean conveyor belt (refer **Figure 2-4**). The eastern archipelago is the only place in the Pacific Ocean that connects with the Indian Ocean at lower latitudes. The water mass transport from the Pacific to the Indian Ocean through various channels in Indonesia is called Arlindo (Arus Lintas Indonesia), also known as the Indonesian Throughflow (ADB 2014). Surface currents in Indonesian waters are more strongly influenced by circulation from the Pacific Ocean than from the Indian Ocean. The currents are also greatly influenced by the winds of the prevailing monsoon.

Average swell heights are low, around 0.4–0.6 m in all months. The greatest exposure to swells is from the west (SSE 1993). Tropical cyclones have generated significant swell heights of up to 5 m in this area, although the predicted frequency of swells exceeding 2 m is less than 5% (WNI 1996). In the open ocean, sustained winds result in wind-forced currents of approximately 3% of the wind speed (Holloway & Nye 1985).

Tides in the South West Capes area are mixed (i.e. diurnal and semi-diurnal) and generally less than one metre, with a typical daily range of about 0.7 m during spring tides and about 0.5 m during neap tides. Tides of this magnitude produce weak currents compared to wind and wave driven flows (Hill & Ryan 2002 cited in DEC 2013).

Waters on the continental shelf are usually thermally-stratified, with a marked change in water density at approximately 20 m (SSE 1993). Surface temperatures vary annually, being warmest in March (32°C) and coolest in August (19°C). Vertical gradients are related to the seasonality of sea surface temperatures, and are greatest during the warm-water season (SSE 1991). Near-bottom water temperature on the North West Shelf is approximately 23°C, with no discernible seasonal variation.

Salinity is relatively uniform at 34–35 ppt throughout the water column and across the North West Shelf. Due to the low rainfall there is little freshwater run-off from the adjacent mainland (Blaber *et al*. 1985).

Pronounced shifts in water column characteristics can occur following the passage of tropical cyclones (McKinnon *et al*. 2003). Changes in water temperature and salinity characteristics can result from changes in local heating and evaporation following the southward movement of warmer water due to southward-moving cyclones, and can have flow-on effects to primary and secondary productivity (McKinnon *et al*. 2003).

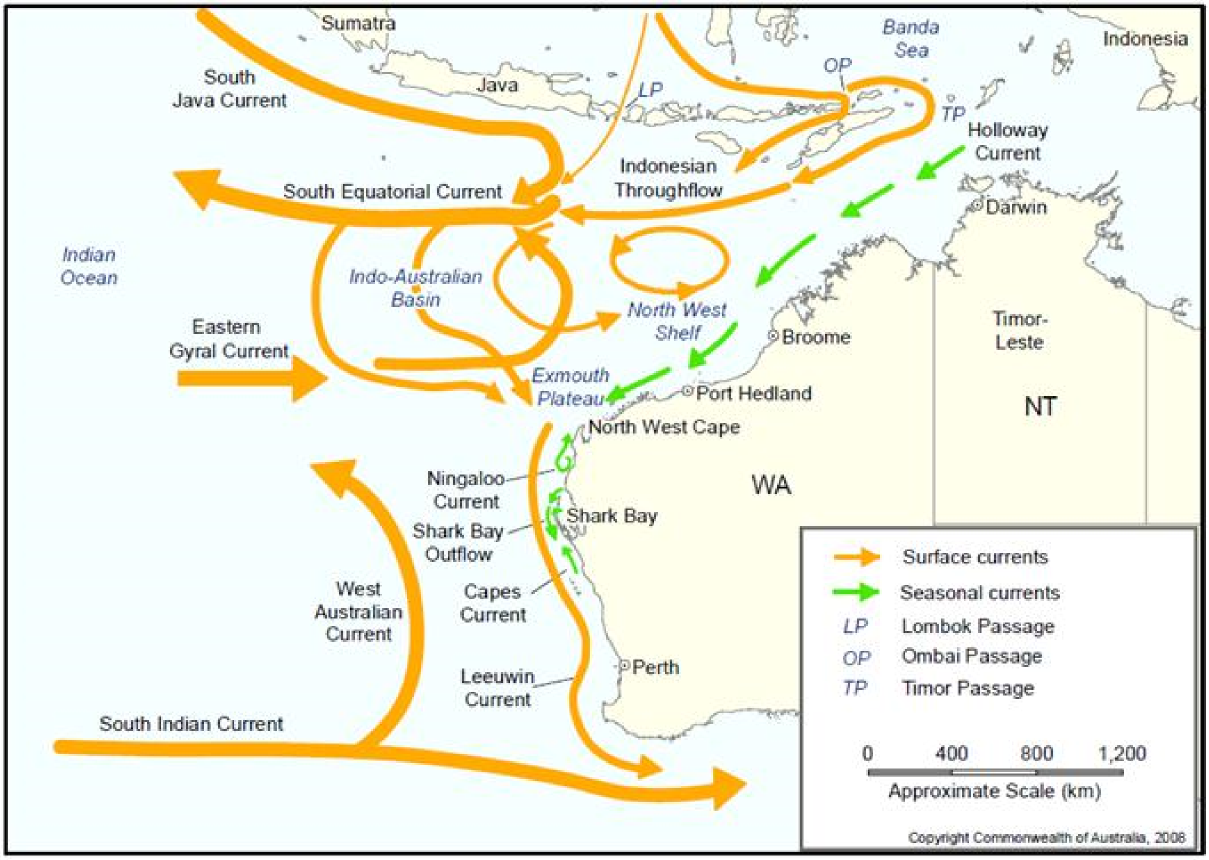

Figure 2-3: Surface currents in WA

Source: DEWHA (2008a)

3. Benthic & Pelagic Habitats

3.1 Coral Reefs

3.1.1 Operational Area

Extensive coral communities are not present within the operational areas or PW mixing zone.

3.1.2 EMBA

The waters in the EMBA contain extensive coral communities. Within the EMBA the following receptors may contain extensive coral reefs:

+ Dampier Archipelago
+ Northern, Middle and Southern Islands Coast (Onslow Region)
+ Montebello Islands
+ Lowendal Islands
+ Barrow Island
+ Thevenard Islands
+ Muiron Islands
+ Exmouth Gulf Coast
+ Ningaloo Region
+ Outer Shark Bay Coast
+ Barrow-Montebello Surrounds
+ Montebello AMP
+ Zuytdorp Cliffs - Kalbarri
+ Shark Bay AMP
+ Offshore Abrolhos NW

Corals are both primary producers and filter feeders and thus play a role in the provision of food to marine fauna and in nutrient recycling to support ecosystem functioning (Conservation and Land Management (CALM) & Marine Parks and Reserves Authority (MPRA) 2005a).

Corals create settlement substrate and shelter for marine flora and fauna. Studies have shown that declines in the abundance, or even marked changes in species composition of corals, has a marked impact on the biodiversity and productivity of coral reef habitats (Pratchett *et al*. 2008). As part of the reef building process, scleractinian corals are also important for protection of coastlines through accumulation and cementation of sediments and dissipation of wave energy (CALM & MPRA 2005a).

Coral reefs in the area fall into two general groups: the fringing reefs around coastal islands and the mainland shore; and large platform reefs, banks and shelf-edge atolls offshore (Woodside 2011). The distribution of corals in area is governed by the availability of hard substrate for attachment and light availability.

The significant coral areas within the EMBA are described below

3.1.2.1 Shark Bay

Studies at Shark Bay recorded 80 species of coral (Marsh 1990). The study determined that salinity and seasonal temperature gradients restrict the distribution of corals to areas that have normal salinity in the western half of the Bay, a few species occur in the metahaline waters but none in the hyper saline areas (Marsh 1990). The eastern shores of Bernier, Dorre and Dirk Hartog Islands provide the most favourable habitats for coral growth due to shelter, and water with relatively small salinity and temperature fluctuations. Some sections of these islands support prolific coral growth (up to 100% cover) both in the sheltered leeward and exposed areas.

Shark Bay is located 335 km away from the operational area and lies within the EMBA.

3.1.2.2 Ningaloo Reef

A significant proportion of the Central Western Shelf Transition province is covered by the. The Ningaloo Reef is unique in that it is the largest fringing reef in Australia and is the only large reef found on the western side of a continent in the southern hemisphere and supports variable lagoonal, intertidal and subtidal coral communities along its length. Ningaloo Reef is characterised by a high diversity of hard corals with at least 217 species representing 54 genera of hermatypic (reef building) corals recorded to date (Veron & Marsh 1988). The most diverse coral communities are found in the shallow relatively clear water, high energy environment of the fringing barrier reef and low energy lagoonal areas to the west of North West Cape (CALM & MPRA 2005a).

Coral diversity reduces with increasing depth, and corals are uncommon at depths greater than 40 m (Waples & Hollander 2008). At depths between 20 and 30 m hard corals have been found to be more dominant in the northern areas of the Ningaloo Marine Park, whereas in southern areas other sessile invertebrates such as sponges, as more prevalent (Waples & Hollander 2008).

Ningaloo Reef is located 27 km from the operational area and exists within the larger EMBA.

3.1.2.3 Rowley Shoals

The Rowley Shoals are three distinct reef systems (Mermaid, Clerke and Imperieuse Reefs) approximately 30–40 km apart that rise vertically to the surface from depths of between 500 and 700 m. The marine reef fauna of the Rowley Shoals is considered to be exceptionally rich and diverse, including species typical of the oceanic coral reef communities of the Indo-West Pacific. As many of these species are not found in the inshore tropical waters of northern Australia, such populations are of regional significance (DEWHA 2008).

A 1993 survey at Mermaid Reef recorded 214 species of scleractinian corals (Done *et al*. 1994). The survey found that coral assemblages of the Rowley Shoals are broadly comparable to those found on the reefs of the outer Great Barrier Reef and in the Coral Sea. While the coral fauna is similar to Scott Reef, it differs considerably from that of north-western Australia (Veron 1986). Veron (1986) notes that the clear water of the Rowley Shoals allows coral communities to exist over a great range of depths, while the strong wave action on the outer coral slopes and the wide tidal range result in distinct patterns of zonation.

Rowley Shoals are located 644km from the operational area and fall within the larger EMBA.

3.1.2.4 Dampier Archipelago

The Dampier Archipelago supports coral reefs in shallow waters near islands and submerged pinnacles. The most significant coral reefs have formed along the seaward slopes of Delambre Island, Hamersley Shoal, Sailfish Reef, Kendrew Island and north-west Enderby Island (CALM & MPRA 2005b). Field trips in the Dampier Archipelago between 1972 and 1998 recorded 229 species of corals from 57 genera (Griffith 2004). Surveys of the Dampier Port and inner Mermaid Sound recorded approximately 120 coral species from 43 genera (Blakeway & Radford 2005) with coral reefs dominated by acroporids and pocilloporids. The greatest coral cover (up to 70%) was recorded in the eastern half of the archipelago (Wells *et al*. 2003).

Dampier Archipelago is 260 km from the operational area and falls within the larger EMBA.

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3.1.2.5 Montebello, Lowendal and Barrow Islands

The Montebello, Lowendal and Barrow Islands include 315 islands associated with extensive coral reefs, the most significant of which occur in the sheltered waters on the eastern side of the islands. Examples of these significant reefs include Dugong Reef, Batman Reef and reefs along the Lowendal Shelf (DEC & MPRA 2007a). Dominant corals include acroporids and poritids, with greater than 70% cover recorded for some areas (Chevron 2010). Subtidal coral reef communities around the islands are highly diverse, with at least 150 species of hard corals recorded from fringing and patch coral reef areas (DEC & MPRA 2007a).

Coral distribution near the mainland is restricted by lack of light due to natural turbidity. Corals may exist as sparse coral colonies in some locations, rather than extensive coral communities. Within Exmouth Gulf, coral communities are less common but are present on fringing reefs surrounding islands, as solitary corals distributed across areas of hard substrate, or on larger isolated patch reefs. Montebello,

Lowendal and Barrow Islands are located 133km from the operational area and fall within the EMBA.

3.1.2.6 Abrolhos Islands

The coral reefs of the Houtman Abrolhos Islands are the most southern extensive coral community along the west coast. Smaller localised pockets do occur as far south as Rottnest Island and even extend to Cape Naturaliste in the Southwest Shelf Province. The reefs around the Abrolhos Islands comprise 211 known species of corals and all but two of the coral species are tropical (Department of Fisheries (DoF) 2012). The greatest diversity and density of corals is found on the reef slopes, shallow reef perimeters and lagoon patch reefs in the more sheltered northern and eastern sides of each of the three limestone platforms that support the island groups (DoF 2012) T

The Abrolhos Islands are 777km from the operational area and fall within the EMBA.

3.1.2.7 Scott Reef

Scott Reef consists of two reefs, North Scott Reef and South Scott Reef, which are separated by a deep (400–700 m) channel. North Scott Reef is an annular reef which encloses a lagoon that is connected to the ocean. South Scott Reef is a crescent-shaped reef which forms an arc and partially encloses another lagoon. Light penetration at Scott reef is high due to low turbidity. Light penetration depths to the deeper part of South Reef Lagoon are in excess of 50m with corals able to survive at depths of up to 70 m (Woodside Energy Limited *et al.* 2010).

Scott Reef is 1,128km from the operational area. It is part of the wider EMBA.

3.1.2.8 Christmas Island

Fringing coral reefs around Christmas Island are relatively simple with 88 coral species previously identified which are identified to support and over 600 fish species (Director of National Parks 2012).

Christmas Island is 1492km from the operational area and lies within the North-west corner of the EMBA.

3.1.2.9 Indonesia and Timor Province

Indonesia has an estimated 75,000 km^2 coral reef ecosystem distributed throughout the archipelago (Tomascik et al. 1997 cited in Hutumo & Moosa 2005). Fringing reefs are the most common reef types with scleractinian corals as being the most dominant and important group. 452 species of hermatypic scleractinian coral were collected from Indonesian waters by Tomascik et al. (1997 cited in Hutumo & Moosa 2005), a study presented by Suharsono (2004 cited in Hutumo & Moosa 2005), indicated that 590 species of scleractinian corals exist in Indonesian waters. Acropora, Montipora and Porites are the most important reef building corals in Indonesia.

The Lesser Sunda Ecoregion encompasses the chain of islands and surrounding waters from Bali, Indonesia to Timor-Leste. This region contains suitable habitat for corals on shallow water substrates formed by limestone and lava flows and is thought to contain more than 500 species of scleractinian reef-building corals (DeVantier *et al.* 2008). Coral species composition is influenced by regional and local scale seasonal upwellings that typically occur from April to May each year on the southern side of the islands. The ecoregion is considered important for coral endemism, particularly the areas of Bali-Lombok, Komodo and East Flores. Fringing coral reefs tend to be less developed on the southern, more exposed shorelines (Wilson *et al.* 2011). Indonesian shorelines dos not fall within the EMBA.

Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam Reefs are areas of enhanced local biological productivity, within an area of relatively unproductive waters. Ashmore Reef National Nature Reserve supports one of the greatest number of coral species of any reef off the West Australian coast, with 255 species of reef-building corals in 56 genera (Veron 1993). Taxonomic revisions and additional surveys have resulted in a net increase in species numbers to 275 (Griffith 1997, Ceccarelli et al. 2011). Species are typical of the Indo-pacific region and none are unique or considered endemic. However, 41 species (15% of the total hard coral species at the site) are listed as vulnerable on the IUCN Red List (IUCN 2019). In 1998, hard coral covered an area of around 717 ha at Ashmore Reef. The majority of hard corals occur in the deep lagoon (265 ha) and shallow reef top (315 ha) with small areas in the shallow lagoons, and reef edge/slope habitats (Skewes et al. 1999a). The soft, non-reef building corals are less well studied at Ashmore Reef than the hard corals (Hale & Butcher 2013). In 1986, 39 soft coral taxa were recorded within the Ashmore Reef, including the vulnerable blue coral (Heliopora coerulea) which was moderately common on the reef flats (Marsh 1993). In 1998, the total cover of soft coral at Ashmore Reef was 323 ha and Sarcophyton spp. was the dominant taxa covering around 19 ha in total (Skewes et al. 1999b, Hale & Butcher 2013).

The Northern portion of the EMBA includes Indonesian waters and Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam Reefs, all of which may contain coral. These areas are approximately 1500 km from the operational area.

3.2 Seagrasses

3.2.1 Operational Area

Seagrasses are not anticipated within the operational area or PW mixing zone.

3.2.2 EMBA

Seagrasses are biologically important for four reasons:

1. As sources of primary production;
2. As habitat for juvenile and adult fauna such as invertebrates and fish;
3. As a food resource; and
4. For their ability to attenuate water movement and trap sediment (Masini *et al*. 2009).

Twenty-five species of seagrass have been recorded in Western Australia, the highest diversity in the world (Masini *et al*. 2009). Waters extending from Busselton to the Northern Territory border support predominantly tropical species although temperate species are also found, particularly between Busselton and Exmouth (Walker and Prince 1987). One species, *Cymodocea angustata*, is endemic to Western Australia (DPAW 2013).

The main seagrasses of the region are small, ephemeral species that grow on soft sediments and have a seed bank in the surficial sediments that allows them to recover quickly from disturbance (Walker 1989). Small, ephemeral species of seagrass tend to form mixed associations with macroalgae (CALM & MPRA 2005b, DEC & MPRA 2007a, BHPBIO 2011) and usually covers less than 5% of the substrate (BHPBIO 2011, van Keulen & Langdon 2011).

Areas occupied by seagrass vary markedly both seasonally and interannually and it is not clear why some areas of suitable substrate will support seagrass in one year but not the next. It appears that recruitment to what may otherwise be suitable substrate is haphazard, lending weight to the descriptions of these seagrass communities as ephemeral (CALM & MPRA 2005b, DEC & MPRA 2007a).

Seagrass are present within the EMBA, extensive habitat is present at:

+ Shark Bay
+ Ningaloo Reed
+ Rowley Shoals
+ Scott Reef
+ Scott Reef
+ Dampier Archipelago
+ Montebello and Barrow Islands
+ Geographe Bay
+ Timor province (including Ashmore reef)

3.2.2.1 Shark Bay

Shark Bay contains the largest reported seagrass meadows in the world (approximately 4,000 km^2), as well as some of the most species-rich seagrass assemblages (Walker 1989). Twelve species of seagrass are found in the Bay with the dominant species being *Amphibolis antarctica*. Seagrass is a fundamental component of biological processes in Shark Bay; it has modified the physical, chemical and biological characteristics of the Bay and provides food, habitat and nursery grounds for many species (CALM & NPNCA 1996).

Shark Bay is located 335 km from the operational area and exists within the larger EMBA.

3.2.2.2 Ningaloo Reef

Nine species of seagrasses have been found throughout Ningaloo Reef (van Keulen & Langdon 2011). Some delineation of temperate and tropical species exists; however, several species were found throughout the Ningaloo Reef. Halophila ovalis was the most commonly found seagrass at Ningaloo and was generally found growing in sandy patches between coral bomboras. Amphibolis antarctica is a large meadow forming species that has been found growing in large clumps in Bateman Bay, north of Coral Bay (van Keulen & Langdon 2011).

Ningaloo Reef is located 27 km from the operational area and exists within the larger EMBA.

3.2.2.3 Rowley Shoals

The Rowley Shoals provide the only suitable shallow substrate for seagrasses in this predominantly deep bioregion. Sparse seagrass is found within subtidal coral reef communities of the Rowley Shoals but is not a major habitat type. Two species of seagrass, *Thalassia hemprichii* and *Halophila ovalis*, have been recorded at Mermaid Reef (Huisman *et al*. 2009). Earlier studies at Mermaid and Imperieuse Reef recorded the above two species and a third species; *Thalassodendron ciliatum* (Walker & Prince 1987).

Rowley Shoals are located 644km from the operational area and fall within the larger EMBA.

3.2.2.4 Scott Reef

Scott Reef supports five species of seagrass (URS 2006), with *Thalassia hemprichii* most abundant (Skewes *et al*. 1999a, URS 2006). The area of seagrass at Scott Reef is significantly less than that recorded for Ashmore Reef (approximately 100 ha) (Woodside 2011). The highly energetic environment and significant tidal exposure of Scott Reef restricts the area of habitats potentially suitable for seagrass establishment to a small proportion of the total area, resulting in low abundance (Skewes *et al*. 1999a, URS 2006).

In addition, Seringapatam Reef was found to have a seagrass cover of 2 ha out of 5,519 ha (0.04%) composed of Thalassia hemprichii and Halophila ovalis in approximately equal quantities (Skewes et al. 1999a). This finding contrasts with a more recent survey where only one species of seagrass (Halophila decipiens) was recorded at Seringapatam (Huisman et al. 2009).

Scott Reef is 1,128km from the operational area and falls within the larger EMBA.

3.2.2.5 Dampier Archipelago

In the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area, seagrass occurs in the larger bays and sheltered flats of the area (CALM & MPRA 2005b). Six species of seagrass, including three Halophila species, have been recorded on the subtidal soft sediment habitats (CALM & MPRA 2005b). Seagrasses do not form extensive meadows within the proposed reserves, but rather form interspersed seagrass/macroalgal beds. The largest areas of seagrass are found between Keast and Legendre islands, and between West Intercourse Island and Cape Preston (CALM & MPRA 2005b).

Dampier Archipelago is 260 km from the operational area and falls within the larger EMBA.

3.2.2.6 Montebello/Barrow Islands

The Montebello/Barrow Islands Marine Conservation Reserves, seagrasses appear not to form extensive meadows but are sparsely interspersed between macroalgae. Seven seagrass species have been recorded in the Reserves (DEC & MPRA 2007a) with *Halophila* spp. the most common seagrass species on shallow soft substrates and sand veneers. Distributions of these species extend from the intertidal zone to approximately 15m water depth (DEC & MPRA 2007a). Surveys to the northwest and southeast of Barrow Island from 2002 to 2004 did not identify any significant seagrass meadows but confirmed the presence of sparse coverage of *Halophila* and *Halodule* spp. in shallow areas east of Barrow Island (RPS BBG 2005).

Lowendal and Barrow Islands are located 133km from the operational area and are included in the wider EMBA.

3.2.2.7 Geographe Bay

Geographe Bay is a large relatively sheltered area with that supports extensive beds of tropical and temperate seagrass that have a high diversity of species and endemism (DEWHA 2008a). They are thought to account for about 80% of benthic primary production in the area. These seagrass beds provide important nursery habitat for many shelf species that use the shallow seagrass habitat as nursery grounds for several years before moving out over the shelf to their adult feeding grounds along the shelf break.

The Geographe Bay seagrass meadows are among the most extensive temperate seagrass communities on the west coast (MPRSWG 1994 cited in DEC 2013), and include 10 species from five genera (Amphibolis, Posidonia, Halophila, Heterozostera and Thalassodendron). Geographe Bay is dominated by stands of the narrowleaf tape-weed (Posidonia sinuosa) that covers approximately 70% of Geographe Bay. It has smaller areas of Posidonia angustifolia, Amphibolis griffithii, A. antarctica and minor species, which have irregular distributions both spatially and temporally (Lord 1995 cited in DEC 2013). Thalassodendron pachyrhizum, Posidonia spp. and Amphibolis spp. are also found in depths of between 27 and 45 m (Walker et al. 1994 cited in DEC 2013).

Geographe Bay is located over 1,000 km from the operational area and are included in the wider EMBA.

3.2.2.8 Indonesia and Timor Province

Seagrass has been reported on the reef flats of offshore reefs of this bioregion (Whiting 1999, Hale & Butcher 2013). Five species of seagrass were reported at Ashmore Reef with Thalassia hemprichii being the dominant species (Pike & Leach 1997, Skewes et al. 1999b, Brown & Skewes 2005). The total area of seagrass at Ashmore Reef in 1999 was estimated to be 470 ha (Skewes et al. 1999b). However, much of this was very sparse cover and there were only 220 ha of seagrass with a greater than 10% cover (Brown & Skewes 2005). Seagrass grew in a sparse, patchy distribution across the sand flats, but had a higher coverage on the reef flat area, where it extended to within 100 m of the reef crest. The area of greatest cover and diversity was in the west and south-west areas of the reef on the inner reef flat (Brown & Skewes 2005). These seagrass meadows support a small but significant population of dugongs estimated at around 100 individuals comprising all age classes from calves to adults (Hale & Butcher 2005).

The Northern portion of the EMBA includes Indonesian waters and Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam Reefs, all of which may contain coral. These areas are approximately 1500 km from the operational area.

3.3 Macroalgae

3.3.1 Operational Area

Significant macroalgae is not anticipated within the operational area or PW mixing zone.

3.3.2 EMBA

Macroalgae are important contributors to primary production and nutrient cycling in the region, providing food and habitat for vertebrate and invertebrate fauna. Macroalgae are also recognised for their role in spatial subsidies; the movement of nutrients or energy between neighbouring habitats. Spatial subsidies involving macroalgae include the movement of wrack from macroalgal beds to bare substrates and shorelines (Orr 2004).

Macroalgae are primarily associated with hard substrates. They occur in moderate to high cover on exposed hard substrates, but typically have lower cover on hard substrates that are covered with a veneer of sediment (SKM 2009, BHPBIO 2011). Macroalgae exhibit very high seasonal and interannual variation in biomass (Heyward *et al*. 2006) and distribution, abundance and biodiversity (Rio Tinto 2009, BHPBIO 2011). The distribution of hard substrates therefore indicates areas that may support macroalgal communities, although abundance and diversity may fluctuate annually.

Macroalgae are susceptible to disturbance from factors such as sedimentation, scouring and turbidity but the marked seasonality in biomass, abundance, diversity and distribution suggests macroalgae are likely to be resilient to acute, short-term disturbance acting at local scales. Macroalgae may be more susceptible to impacts acting over longer time scales (years) and at certain times of the year, where recruitment at a regional scale could be affected. Indirect impacts affecting the numbers, distribution and community structure of herbivorous fish can also be expected to have impacts (either positive or negative) on macroalgal habitats (Vergès *et al*. 2011).

Macroalgae is present within the wider EMBA, extensive areas are present at:

- Dampier Archipelago
- Montebello, Lowendal and Barrow Islands
- Ningaloo Coastline
- Indonesia and Timor province
- Abrolhos Islands

3.3.2.1 Dampier Archipelago

Macroalgae dominate shallow (<10 m) submerged limestone reefs and also grow on stable rubble and boulder surfaces in the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area (CALM & MPRA 2005b). Huisman and Borowitzka (2003) reported approximately 200 species of macroalgae from the Dampier Archipelago. Low relief limestone reefs that are dominated by macroalgae, account for 17% (approximately 35,460 ha) of the marine habitats within the proposed Marine Management Area (CALM 2005a).

Dampier Archipelago is 260 km from the operational area and falls within the larger EMBA.

3.3.2.2 Montebello/ Lowendal/ Barrow Islands

Macroalgae occupy approximately 40% of the benthic habitat area in the Montebello/ Lowendal/ Barrow Island region (CALM 2005b). At least 132 macroalgal taxa occur around Barrow Island, with most thought to be widely distributed in the tropical Indo-Pacific region (Chevron 2005).

Macroalgae monitoring around the Lowendal and Montebello Islands since 1996 (The Ecology Lab 1997, IRCE 2002 2003 2004 2006 2007, URS 2009) has found macroalgal cover and biomass to be naturally spatially and temporally variable. *Sargassum* spp. represented 70% of the macroalgal assemblage in 2009, compared to 96% in 2002 (URS 2009). Sargassum spp. cover as a percentage of total macroalgae cover was significantly lower in 2009 than in previous years, primarily due to an increase in filamentous algae at a number of sites (URS 2009).

Lowendal and Barrow Islands are located 133km from the operational area and are included in the wider EMBA.

3.3.2.3 Ningaloo Coastline

Macroalgal beds along the Ningaloo coastline are generally found on the shallow limestone lagoonal platforms and occupy about 2,200 ha of the Ningaloo Marine Park and Muiron Islands Marine Management Area (CALM & MPRA 2005a). Macroalgal communities within the area have been broadly described (Bancroft & Davidson 2001). The dominant genera are the brown algae *Sargassum*, *Padina*, *Dictyota* and *Hydroclathrus* spp. (McCook et al. 1995).

Ningaloo coast is located 35 km from the operational area and exists within the larger EMBA.

3.3.2.4 Indonesia and Timor Province

Macroalgae at Ashmore Reef are estimated to cover over 2,000 ha, mostly on the reef slope and crest areas (Hale & Butcher 2013). The algal community is dominated by turf and coralline algae, with fleshy macroalgae comprising typically less than 10% of total algal cover (Skewes et al. 1999b).

Surveys at Scott and Seringapatam Reefs recorded over 100 species of marine algae (Huisman et al. 2009). The marine algal community was similar between reefs and also similar to the Rowley Shoals. Algae found at these offshore atolls forms a small subset of the Indo-Pacific algal flora, with virtually all of the species identified thus far having been previously collected from north-western Australia or from localities further north. Although further research is necessary, at present there is nothing to suggest that the macroalgae communities of these offshore atolls are unique within the Indo-Pacific (Huisman et al. 2009).

The Northern portion of the EMBA includes Indonesian waters and Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam Reefs, all of which may contain coral. These areas are approximately 1500 km from the operational area.

3.3.2.5 Abrolhos Islands

The Houtman Abrolhos have known species of benthic algae with macroalgae communities considered important in supporting a diversity of marine life.

More than 340 species of macroalgae (including 54 species of green algae, 71 species of brown algae, and 222 species of red algae) have been recorded from rock platforms around Rottnest Island (Amalfi 2006).

The Abrolhos Islands are 777km from the operational area and fall within the EMBA.

3.3.2.6 North of Broome and Kimberley

There is a lack of information regarding the marine benthic flora of north-west Western Australia and no comprehensive marine flora list exists for the region (Huisman 2004). However, about 70 algae species were collected during a survey of intertidal reefs on the central Kimberley coast in 1997 (Walker 1997).

Tropical macroalgae species are typically associated with areas of hard substrate and various types of macroalgae occur on rock platforms intermingled with coral and sponge. Abundance and biomass typically exhibit strong seasonal trends (Heyward et al. 2006).

The diversity and abundance of algae in the Kimberley is probably linked to the region's extreme tidal exposure and highly turbid waters, reducing light penetration and resulting in deposition of fine sediments (Walker 1997). However, the role of algae appears crucial to the growth of reefs in the highly turbid waters of the Kimberley coast and islands (Brooke 1997). Sargassum spp. and coralline algae may be dominant (DPAW 2013).

3.4 Non-Coral Benthic Invertebrates

3.4.1 Operational Area and PW mixing zone

Within the operational area, soft sediment is the dominant habitat. A survey of seabed habitat has previously been conducted at the Coniston/Novara fields (RPS, 2011a) and at the Van Gogh Field (Apache, 2009). The seabed survey at the Coniston/Novara fields, along the flowlines and production manifold locations, has revealed a flat soft sediment habitat comprising sand, silt and mud with a sparse epibenthic fauna (including anemones, sea stars, soft corals, crabs, shrimp and sea urchins) and an infaunal community dominated by polychaetes and crustaceans. This survey found no unique communities or communities of particular regional significance (RPS, 2011a). Similarly, a seabed survey at the Van Gogh field has revealed a flat substrate comprising mud and silts sediments with sparse epifauna (including sponges, echinoderms and crustaceans) and an infaunal community comprising mainly polychaetes and crustaceans (Apache, 2009).

Within the larger PW mixing zone, the benthic habitat is expected to be similar to that within the operational area comprising predominantly soft sediments with a sparse epi-benthic community. The depth of the operational area and PW mixing zone (>300 m) precludes the existence of benthic primary producers (i.e. photosynthetic organisms including hard corals, seagrasses and macroalgae), which are typical of shallower coastal areas, as seabed light availability at these depths is insufficient to support photosynthesis

3.4.2 EMBA

The EMBA contains a wide range of non-coral benthic invertebrates. Extensive areas of non-coral benthic invertebrates are present at:

+ Dampier Archipelago
+ Rowley Shoals
+ Ningaloo Reef
+ Shark Bay
+ Barrow Island
+ Ashmore Reef

In 2007, CSIRO conducted extensive benthic habitat mapping surveys and epibenthic fauna (living on the surface and ≥1 cm body size) sampling in deep waters (100–1,000 m) spanning thirteen sites between Barrow Island and Ashmore Reef running along the continental shelf and across the continental slope of the North West Shelf (Williams *et al*. 2010). At the continental shelf margin (~100 m water depth) Williams *et al*. (2010) reported that similar benthic habitats occurred at each survey site across the breadth of the North West Shelf. Benthic habitats at this depth comprised a mix of riffled muddy sand (sometimes as a veneer over rocky subcrops) together with gravel to pebble-sized rubble, cobbles, boulders and some rock outcrops. Typical epifauna found at these depths included scattered isolated hydroids, sea fans and soft corals and often small sponges. Other fauna observed at some of the sites included scattered isolated sea whips, crinoids, sea pens, urchins and anemones. Epibenthic fauna along the continental shelf margin were quantified as sparse and low diversity (Williams *et al*. 2010). Modelling indicated that a trawl sample of 1 km length would generally be expected to yield approximately 80 individuals represented by 15 species (Williams *et al*. 2010) in 100 m depth waters.

Baseline studies undertaken in nearshore areas of the Pilbara (SKM 2009, Rio Tinto 2009, BHPBIO 2011) and offshore areas around Barrow Island (Chevron 2010) have shown that filter feeder communities are a dominant component of benthic habitats in depths >10 m where reduced light appears to inhibit extensive development of hard corals and macroalgae. The pavement habitats between Barrow Island and the mainland are covered by a sediment veneer that appears to periodically move, exposing areas of pavement reef. Sessile benthic organisms that require hard substrates for attachment, such as gorgonians, are frequently seen emerging through a shallow veneer of sand. This type of substrate (sediment veneer) with sparse filter feeder communities is common throughout this area (SKM 2009, Rio Tinto 2009, BHPBIO 2011).

Stromatolites occur in Shark Bay. Although they are a microbial colony (prokaryote), and not an invertebrate (eukaryote), they are described here as a unique benthic biological community. Stromatolites are rock-like structures built by cyanobacteria. Shark Bay's stromatolites are 2,000 to 3,000 years old and are similar to life forms found on Earth up to 3.5 billion years ago. Until about 500 million years ago, stromatolites were the only macroscopic evidence of life on the planet; hence they provide a unique insight into early life forms and evolution. The stromatolites are located in the hypersaline environment of Hamelin Pool and are one of the reasons for the area's World Heritage Listing (DPAW 2009).

Some sponge species and filter-feeding communities found in deeper waters offshore from the Ningaloo Reef appear to be significantly different to those of the Dampier Archipelago and Abrolhos Islands, indicating that the Commonwealth waters have some areas of potentially high and unique sponge biodiversity (Rees *et al*. 2004).

Due to contrasting depths, the Rowley Shoals supports a diverse marine invertebrate community including a number of endemic species. Invertebrate species (excluding corals) at the Rowley Shoals include sponges, cnidarians (jellyfish, anemones), worms, bryozoans (sea mosses), crustaceans (crabs, lobsters, etc.), molluscs (cuttlefish, baler shells, giant clams, etc.), echinoderms (starfish, sea urchins) and sea squirts (DEC & MPRA 2007b).

3.5 Plankton

Plankton abundance and distribution is patchy, dynamic and strongly linked to localised and seasonal productivity (Evans *et al.* 2016). Fluctuations in abundance and distribution occur both vertically and horizontally in response to tidal cycles, seasonal variation (light, water temperature and chemistry, currents and nutrients) and cyclonic events. As a key indicator for ecosystem health and change, Plankton distribution and abundance has been measured for over a century in Australia (Richardson *et al.* 2015). The compilation of this data has been made publicly available through the Australian Ocean Data Network (Australian Ocean Data Network 2017) and has recently been used in the Australia State of the Environment 2016 report (Jackson *et al.* 2017) to nationally assess marine ecosystem health. According to their findings, warming ocean temperatures has extended the distribution of tropical phytoplankton species (which have a lower productivity), further south resulting in a decline in primary productivity in oceanic waters north of 35°C, especially the North West Shelf (Evans *et al.* 2016). Trends of primary productivity across Australia are however variable with the South West of Australia experiencing an increase in productivity and northern Australia experiencing no change between 2002-2016 (Evans *et al.* 2016).

Within the EMBA, peak primary productivity varies on a local and regional scale. In general, these peaks are linked to mass coral spawning events, peaks in zooplankton and fish larvae abundance and periodic upwelling. Regional upwelling is most common close to the coast and where surface waters diverge. Despite the suppression of major upwelling along the WA coast by the Leeuwin Current, known key upwelling regions include the Ningaloo region (Hanson & McKinnon 2009) & Cape Mentelle (Pattiaratchi 2007). It is also expected that a high abundance of plankton will occur within areas of localised upwelling in the EMBA where the seabed disrupts the current flow.

4. Shoreline Habitats

Shoreline habitats are defined as those habitats that are adjacent to the water along the mainland and of islands that occur above the LAT and most often in the intertidal zone.

The following section broadly categorises shoreline habitats as the following biological communities; mangroves, intertidal mud/sand banks, beaches, and rocky shores. These communities are discussed in **Sections 4.1- 4.5**, in terms of the IMCRA bioregions where relevant and where information is available. Only the bioregions which intersect the EMBA, as defined in the Ningaloo Vision Operations EP are described below,

4.1 Mangroves

Mangroves commonly occur in sheltered coastal areas in tropical and sub-tropical latitudes (Kathiresan and Bingham, 2001). Up to eight species of mangroves are found further north in the Central Western Shelf Transition region, but at most locations the dominant mangrove (in terms of area of intertidal zone occupied) is *Avicennia marina*, with the stilt rooted mangrove *Rhizophora stylosa* often occurring as thin zones of dense thickets within the broad zone of *A. marina*. Mangroves are found wherever suitable conditions are present including wave dominated settings of deltas, beach/dune coasts, limestone barrier islands and ria/archipelago shores (Semeniuk 1993). Mangrove plants have evolved to adapt to fluctuating salinity, tidal inundation and fine, anaerobic, hydrogen sulfide rich sediment (Duke *et al.* 1998).

Mangroves are important primary producers and have a number of ecological and economic values.

For example, they play a key role in reducing coastal erosion by stabilising sediment with their complex root systems (Kathiresan and Bingham 2001). They are also recognised for their capacity to help protect coastal areas from the damaging effects of erosion during storms and storm surge. Mangroves are also important in the filtration of run-off from the land which helps maintain water clarity for coral reefs which are often found offshore in tropical locations (NOAA 2010). The intricate matrix of fine roots within the soil also binds sediments together.

Mangroves play an important role in connecting the terrestrial and marine environments (Alongi 2009). Numerous studies (e.g. Nagelkerken *et al.* 2000, Alongi 2002, 2009, Kathiresan and Bingham 2001) have shown mangroves to be highly productive and an important breeding and nursery areas for juvenile fish and crustaceans, including commercially important species (Kenyon *et al*. 2004). They also provide habitat for many juvenile reef fish species.

Mangroves also play an important ecosystem role in nutrient cycling and carbon fixing (NOAA 2010). The trees absorb carbon dioxide from the atmosphere and the organic matter such as fallen leaves forms nutrient rich sediments creating a peat layer that stores organic carbon (Alongi 2009, Ayukai 1998). For these reasons the EPA of Western Australia recognise mangroves as Benthic Primary Producer Habitat (BPPH), defined as "functional ecological communities that play important roles in maintaining the integrity of marine ecosystems and the supply of ecological services" (EPA 2009).

The muddy sediments that occur in mangrove forests are home to a variety of epibenthic, infaunal and meiofaunal invertebrates (Kathiresan and Bingham 2001). Crustaceans known to inhabit the mud in mangrove systems include fiddler crabs, mud crabs, shrimps and barnacles. Within the water channels of the estuary, various finfish are found from the smaller fish such as gobies and mudskippers (which are restricted to life in the mangroves) through to larger fish such as barramundi (*Lates calcarifer*) and the mangrove jack (*Lutjanus argentimaculatus).* Mangroves and their associated invertebrate-rich mudflats are also an important habitat for migratory shorebirds from the northern hemisphere, as well as some avifauna that are restricted to mangroves as their sole habitat (Garnet and Crowley 2000).

The three key State regulatory documents relevant to the protection and management of mangroves in Western Australia are:

- EPA (2001) Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline. Guidance Statement No. 1;

- EPA (2011) Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland; and
- EPA (2016) Technical Guidance – Protection of Benthic Communities and Habitats.
- Mangroves are not present within the operational area or PW mixing zone, however are present within the wide EMBA as discussed below.

Within the EMBA extensive areas of mangroves are present at:

- Shark Bay
- Ningaloo Coast
- Pilbara Region
- Exmouth Gulf
- Montebello, Barrow and Lowendal Islands

4.1.1 Shark Bay

Shark Bay (in the Central Western Shelf Province) supports the southern-most area of substantial mangrove habitat in Western Australia (Rule *et al*. 2012). The mangroves of Shark Bay comprise only one species, the white mangrove *Avicennia marina*, and these trees occur around the coastline in widely dispersed and often isolated stands of varying size.

Shark Bay is located 335 km from the operational area and exists within the larger EMBA.

4.1.2 Ningaloo Coast

The regional mangroves from Exmouth to Broome (within the Central Western Shelf Transition and southern part of the Northwest Shelf Province) represent Australia's only 'tropical-arid' mangroves. The most significant stand of mangroves in the Central Western Shelf Transition is Mangrove Bay on the western side of the Cape Range Peninsula in the Ningaloo Marine Park. This small area of mangrove (37 ha) represents the largest area of mangrove habitat within the Ningaloo Marine Park and is considered extremely important from a biodiversity conservation perspective (CALM 2005).

Ningaloo coast is located 35 km from the operational area and exists within the larger EMBA.

4.1.3 Pilbara Region

In the Pilbara region, the coast is a complex of deltas, limestone barrier islands and lagoons, with a variable suite of substrates. As a result, mangroves in this region form relatively diverse fringing stands, albeit often stunted in stature but at times quite extensive in area. The mangroves along the Pilbara coastline are the largest single unit of relatively undisturbed tropical arid zone habitats in the world. The area has nine mangrove taxa and a total of 632 km^2 mangroves (MangroveWatch 2013). As with most arid zone mangroves, Pilbara mangroves are characterised by open woodlands and shrublands that are of relatively lower productivity than the mangrove communities of the wet tropics because of the extreme water and salinity stresses that affect the intertidal zone in the Pilbara (EPA 2001). Significant stands of mangroves in the Pilbara include:

- Exmouth Gulf: mangrove assemblages within the Bay of Rest on the western shore of the Gulf and the extensive mangrove system on the eastern shore of the Gulf that extends as a series of tidal flats and creek channels from Giralia Bay to Yanrey Flats (Astron 2014). These areas of mangrove are also designated as 'regionally significant' by the EPA (2001). The importance of these mangroves to the Exmouth Prawn Fishery is discussed in Kangas *et al*. (2006);
- Mainland coast and nearshore islands: mangrove assemblages at Ashburton River Delta, Coolgra Point, Robe River Delta, Yardie Landing, Yammadery Island and the Mangrove Islands are all designated as 'regionally significant' by the EPA (2001) and the EPA will give these mangrove

formations the highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function;

Exmouth Gulf mangroves are located 100 km from the operational area and are included in the wider EMBA.

4.1.4 Montebello, Barrow and Lowendal Islands:

Nangrove assemblages all lay within designated reserves. The mangrove communities of the Montebello Islands are considered globally unique as they occur in lagoons of offshore islands (DEC 2007). Mangrove stands identified on Varanus Island occur on the west coast in discrete patches within the tidal and supratidal zones, at South Mangrove Beach and a small embayment (Astron 2016). Mangrove stands on Varanus Island have been identified as healthy, with similar stands also identified as present on Bridled Island to the north of Varanus Island (Astron 2016).

Lowendal and Barrow Islands are located approximately 130 km from the operational area and are included in the wider EMBA.

4.2 Intertidal Mud/Sand Flats

Intertidal mud / sandflats are not present within the operational area or PW mixing zone, however are present within the wide EMBA. Within the EMBA extensive areas of intertidal mud / sandflats are present at:

+ Shark Bay

Intertidal mudflats form when fine sediment carried by rivers and the ocean is deposited in a low energy environment. Tidal mudflats are highly productive components of shelf ecosystems responsible for recycling organic matter and nutrients through microbial activity. This microbial activity helps stabilise organic fluxes by reducing seasonal variation in primary productivity which ensures a more constant food supply (Robertson 1988). Intertidal sand and mudflats support a wide range of benthic infauna and epifauna which graze on microscopic algae and microbenthos, such as bivalves, molluscs, polycheate worms and crustaceans (Zell 2007).

The high abundance of invertebrates found in intertidal sand and mudflats provides an important food source for finfish and shellfish which swim over the area at high tide. Mudflats have also been shown to be significant nursery areas for flatfish. During low tide, these intertidal areas are also important foraging areas for indigenous and migratory shorebirds. Mudflats also play a vital role in protecting shorelines from erosion (Wade and Hickey 2008).

4.2.1 Shark Bay

Shark Bay in the Central Western Shelf Province has an EPBC protected intertidal ecological community ‘Subtropical and Temperate Coastal Saltmarsh’. It is the northerly limit for this community and there is a transition zone for many saltmarsh species (CALM 1996). The EPBC ‘Listed Advice’ (DoE 2014) reports that sediments associated with these communities generally consist of poorly-sorted anoxic sandy silts and clays, and may have salinity levels that are much higher than seawater due to evaporation. The drainage characteristics of coastal soils, along with tidal patterns and elevation, can strongly influence the distribution of flora and fauna within the Coastal Saltmarsh ecological community (DoE 2014).

Shark Bay is located 335 km from the operational area and exists within the larger EMBA.

4.3 Intertidal Platforms

Intertidal platforms are areas of hard bedrock and/ or limestone with or without a sediment veneer of varying thickness. These platforms can vary from low to high relief and provide a habitat for a diverse range of intertidal organisms (Morton and Britton in Jones 2004, SKM 2009, 2011, Hanley and Morrison

2012) and some species of shore birds (Garnet and Crowley 2000). They are common within each of the coastal bioregions within the EMBA.

Limestone pavements extend out from the beach into subtidal zones, e.g. along the Ningaloo Coast and North West Cape; and higher relief platforms (>0.5 m off high water mark) are also present at a number of headlands along the North West Cape.

4.4 Sandy Beaches

Sandy beaches are those areas within the intertidal zone where unconsolidated sediment has been deposited (and eroded) by wave and tidal action. Sandy beaches can vary from low to high energy zones; the energy experienced influences the beach profile due to varying rates of erosion and accretion. Sandy beaches are found across the EMBA and vary in length, width and gradient. They are interspersed among areas of hard substrate (e.g. sandstone) that form intertidal platforms and rocky outcrops. There is a wide range of variation in sediment type, composition, and grain size along the EMBA.

Sandy beaches provide habitat to a variety of burrowing invertebrates and subsequently provide foraging grounds for shorebirds (Garnet and Crowley 2000). The number of species and densities of benthic macroinvertebrates that occur in the sand are typically inversely correlated with sediment grain-size and exposure to wave action, and positively correlated with sedimentary organic content and the amount of detached and attached macrophytes (Wildsmith *et al.* 2005). However, the distributions of these faunas among habitats will also reflect differences in the suite of environmental variables that characterize those habitats (Wildsmith *et al.* 2005).

Sandy habitats are important for both resident and migratory seabirds and shorebirds. While sand flats and beaches generally support fewer species and numbers of birds than mudflats of similar size; some species such as the beach thick knee (*Esacus giganteus*) a crab eater, are commonly associated with sandy beaches (Garnet and Crowley 2000). Sandy beaches can also provide an important habitat for turtle nesting and breeding (see marine reptile turtle **Section 6**).

Sandy beaches are not present within the operational area or PW mixing zone, however are present within the wide EMBA. Within the EMBA extensive areas of sandy beaches are present at:

+ Shark Bay
+ Roebuck Bay and Eighty Mile beach
+ Ningaloo Coast
+ Abrolhos Islands

Eighty Mile Beach Marine Park is one of the Australia's largest uninterrupted sandy beaches (stretching 220 km) and is an important feeding grounds for small wading birds that migrate to the area each summer, travelling from countries thousands of kilometres away (DEC 2012). It is also a listed Ramsar wetland (see **Section 9** on Protected Areas).

4.5 Rocky Shorelines

Rocky shorelines are found across the EMBA and are often indicative of high energy areas (wave action) where sand deposition is limited or restricted (perhaps seasonally or during a cyclone). Within the EMBA extensive areas of rocky shorelines are present at:

+ Shark Bay
+ Roebuck Bay and Eighty Mile beach
+ Ningaloo Coast

Rocky shorelines are formed from limestone pavement extending out from the beach into subtidal zones, for example along the Ningaloo Coast and North West Cape; higher relief platforms (>0.5 m off high water mark) are also present at a number of headlands along the North West Cape. This habitat is also widespread heading south towards Perth.

Rocky shores can include pebble/ cobble, boulders, and rocky limestone cliffs (often at the landward edge of reef platforms). Rocky outcrops typically consist of hard bedrock, but some of the coastline has characteristic limestone karsted cliffs with an undercut notch. Rocky shorelines can vary from habitats where there is bedrock protruding from soft sediments to cliff like structures that form headlands. Rocky shorelines are an important foraging area for seabirds and habitat for invertebrates found in the intertidal splash zone (Morton and Britton in Jones 2004). For example, oyster catchers and ruddy turnstones feed along beaches and rocky shorelines (see seabirds in **Section 8.2.2**).

5. Fish and Sharks

Fish distributions in the EMBA are discussed with respect to the IMCRA Provincial Bioregions which were defined using CSIRO's 1996 regionalisation of demersal fish on the continental shelf to the shelf break, and their 2005 regionalisation of demersal fish on the continental slope to approximately 1,200 m depth (DEH 2006). The EPBC species listed as threatened and migratory found in the EMBA, according to the Protected Matters search (**Appendix D2 and D3**), are shown in **Table 5-1** along with their WA conservation listing (as applicable) and discussed in **Section 5.1.2** below.

The following WA conservation codes apply to WA conservation significant fauna:

- Threatened Species (listed under *Biodiversity Conservation Act 2016*):
  - Critically Endangered
  - Endangered
  - Vulnerable
- Specially protected species (listed under *Biodiversity Conservation Act 2016*):
  - Migratory
  - Species of special conservation interest (conservation dependant fauna)
  - Other specially protected species
- Priority species (non-statutory state based administrative process):
  - Priority 1, 2 and 3: poorly-known species – possible threatened species that do not meet survey criteria or are otherwise data deficient. Ranked in order of priority. In urgent need of further survey.
  - Priority 4: species that are adequately known, are either: rare but not threatened; meet criteria for near threatened; or delisted as threatened species within last five years for reasons other than taxonomy. Requiring regular monitoring.

A detailed account of commercial and recreational fisheries that operate in the region is provided in in the Commercial Fisheries **Section 14.6** and detailed in *The State of the Fisheries Report* 2017/2018 (Gaughan *et al.*, 2019).

Table 5-1: EPBC listed fish and shark species in the EMBA

Species	Conservation Status			Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016* [1]	Other WA Conservation Code		
Blind gudgeon (*Milyeringa veritas)*	Vulnerable	Vulnerable	-	Species or species habitat known to occur within area.	None - No BIA defined
Balstons pygmy perch (*Nannatherina balstoni*)	Vulnerable	Vulnerable	-	Species or species habitat likely to occur within area.	None - No BIA defined

[1] The Wildlife Conservation (Specially Protected Fauna) Notice 2018 has been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.

Species	Conservation Status			Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016* [1]	Other WA Conservation Code		
Blind cave eel (*Ophisternon candidum)*	Vulnerable	Vulnerable	-	Species or species habitat known to occur within area.	None - No BIA defined
Grey nurse shark (*Carcharias taurus*)	Vulnerable	Vulnerable	-	Species or species habitat known to occur within area.	None - BIA not found in EMBA
Great white shark (*Carcharodon carcharias*)	Vulnerable & Migratory	Vulnerable	-	Foraging, feeding or related behaviour known to occur within area	Yes – Refer to **Table 5-3**
Whale shark (*Rhincodon typus*)	Vulnerable & Migratory	Specially protected (species otherwise in need of special protection)	-	Foraging, feeding or related behaviour known to occur within area	Yes – Refer to **Table 5-3**
Northern river shark (*Glyphis garricki)*	Endangered		Priority 1	Breeding likely to occur within the area.	None - BIA not found in EMBA
Dwarf sawfish (*Pristis clavata)*	Vulnerable & Migratory		Priority 1	Breeding known to occur within area	None – BIA not found in EMBA
Freshwater sawfish (*Pristis pristis)*	Vulnerable & Migratory		Priority 3	Species or species habitat known to occur within area.	None – BIA not found in EMBA
Narrow sawfish (*Anoxypristis cuspidate)*	Migratory	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Green sawfish (*Pristis zijsron)*	Vulnerable & Migratory	Vulnerable	-	Breeding known to occur within area	None _ BIA not found in EMBA
Shortfin mako *(Isurus oxyrinchus)*	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Longfin mako *(Isurus paucus)*	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Reef manta ray	Migratory	-	-	Species or species habitat	None - No BIA defined

Species	Conservation Status			Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016* [1]	Other WA Conservation Code		
(Manta alfredi)				known to occur within area	
Giant manta ray *(Manta birostris)*	Migratory	-	-	Species or species habitat known to occur within area	None - No BIA defined
Porbeagle *(Lamna nasus)*	Migratory	-	-	Species or species habitat may occur within area	None - No BIA defined

In addition a review of conservation dependent species[2] identified five species of fish / sharks that may occur in the EMBA:

+ Orange roughy (Hoplostethus atlanticus);
+ Southern blue fin tuna (*Thunnus maccoyii*);
+ Southern dogfish (Centrophorus zeehaani);
+ School shark (*Galeorhinus galeus*); and
+ Scalloped hammerhead (*Sphyrna lewini*).

5.1 Regional Surveys

Within the EMBA a number of important geographical areas for fish exist, including Ningaloo Marine Park, Montebello/Barrow Island Marine Park and the Rowley Shoals.

The following sections present information on fish species within each of the bioregions detailed within **Section 1** which overlap the EMBA.

5.1.1 Southwest Shelf Province

At least 150 species have been identified within the capes region as being reef-associated (Hutchins 1994 cited in DEC 2013). Of these, 77% are warm temperate species, 18% are subtropical species and 5% are tropical (DEC 2013).

The most abundant finfish species across the region identified during surveys were the Maori wrasse (*Opthalmolepis lineolatus*), red banded wrasse (*Pseudolabrus biserialis*), McCulloch scalyfin (*Parma mccullochi*), and western king wrasse (*Coris auricularis*). The yellow headed hulafish (*Trachinops noarlungae*), black headed puller (*Chromis klunzingeri*), rough bullseye and common bullseye (*Pempheris multiradiata* and *P. klunzingeri*) were also common at Eagle Bay and Geographe Bay (Westera *et al.* 2007 cited in DEC 2013).

5.1.2 Southwest Shelf Transition

A total of 389 finfish species have been recorded at the Abrolhos (DoF 2012). The Abrolhos and their surrounding coral and limestone reef systems consist of a combination of abundant temperate macroalgae with coral reefs, supporting substantial populations of large species such as baldchin groper and coral trout. Some of the species occurring in the Abrolhos are dependent on larvae carried

[2] Conservation dependent species are listed species under the EPBC Act and are considered as part of the Commonwealth marine area.

southward by the Leeuwin Current from areas further north, such as Shark Bay or Ningaloo Reef. Similarly, populations of some of the species occurring at Rottnest Island are dependent on larvae generated from breeding populations at the Abrolhos (DoF 2012).

More than 20 species of sharks have been identified at the Abrolhos (DoF 2012). These sharks include:

- Port Jackson sharks (Heterodontus portusjacksoni);
- Tiger shark (Galeocerdo cuvier);
- Whaler sharks (Carcharhinus brachyurus); and
- Wobbegongs (Orectolobus maculatus).

Abrolhos waters are considered to be an important food source for sharks, due to the resident fish populations. Various species of rays have been recorded at the Abrolhos. These include the manta ray and the white spotted eagle ray (DoF 2012).

5.1.3 Central Western Province

The Perth Canyon appears to be an important ecological feature attracting krill and fish aggregations that in turn attract larger species such as predatory fish and pygmy blue whales (DSEWPaC 2012). Demersal slope fish assemblages in this bioregion are characterised by high species diversity. Scientists have described 480 species of demersal fish that inhabit the slope of this bioregion and 31 of these are considered endemic to the bioregion. Demersal fish on the slope in this bioregion in particular have high species diversity compared with other more intensively sampled oceanic regions of the world. Below 400 m water depth demersal fish communities are characterised by a diverse assemblage where relatively small, benthic species (grenadiers, dogfish and cucumber fish) dominate.

5.1.4 Central Western Shelf Province

The Central Western Shelf Province is located near Shark Bay and is the northern limit of a transition region between temperate and tropical marine fauna. Of the 323 fish species recorded from Shark Bay, 83% are tropical species with 11% warm temperate and 6% cool temperate species (CALM 1996).

5.1.5 Central Western Shelf Transition

Ningaloo is the largest fringing coral reef in Australia, forming a discontinuous barrier that encloses a lagoon that provides habitat for many fish species. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). Ningaloo Reef is a well-known biodiversity hotspot, supported by the direct link between the reef and the ancient reef systems found closer to the equator by the Leeuwin Current (Kemps 2010). Approximately 500 species of fish have been reported to inhabit the reef (Kemps 2010). The Piercam project from inception in 2005 to 2013, identified 165 fish species from 50 families at the Point Murat Navy Pier alone, located within the Ningaloo Marine Park (Whisson & Hoschke 2013).

Seasonal aggregations of whale sharks occur at Ningaloo each year (CALM 2005). There is limited data available on species diversity and distribution of sharks in the Ningaloo area as chondrichthyan biodiversity for the area has not been specifically recorded. Despite this, it is possible that the Ningaloo Reef Marine Park contains the largest and most diverse collection of sharks on the Australian coastline (Stevens *et al.* 2009). It was estimated in 2009 by Last and Stevens (cited in Stevens *et al.* 2009), that there are likely to be 118 species of chondrichthyan fishes occurring in the park. Of these species, 59 are shark species predicted to be found at depths of less than 200 m (Stevens *et al.* 2009).

The lagoon at Ningaloo Reef appears to provide a juvenile habitat and nursery area for shark species such as the grey nurse shark (*C. Taurus*), black-tipped reef shark (*Carcharhinus melanopterus*) and other reef sharks (Carcharhinidiae) (Stevens *et al.* 2009). A study conducted on the distribution and abundance of elasmobranches in the Ningaloo Marine Park, in 2009, tracked the movements of six key shark species. Species such as *Galeocerdo cuvier* (tiger shark) and *Sphyrna mokarran* (great hammerhead) were found to remain for brief time periods in the park, in contrast to other species found to re-visit the Ningaloo area (Stevens *et al.* 2009). Several species of sharks within Ningaloo have been identified as key indicator species for the health of the system (Stevens *et al.* 2009).

Barrow Island includes Biggada Reef, an ecologically significant fringing reef, and the Montebello Islands comprise over 100 islands, the majority of which are rocky outcrops; providing fish habitat (DEC 2007a). Within the Barrow/Montebello region, at least 380 fish species have been recorded (de Lestang & Jankowski 2017). Most species exhibit wide distributions, with local species composition closely resembling that of the Dampier Archipelago. Coral habitats support the most diverse fish community in this region, comprising, among others, many species of damselfish (*Pomacentridae*), parrotfish (*Scaridae*), snappers (*Lutijanidae*) and groupers (*Serranidae*) (de Lestang & Jankowski 2017). The region's macroalgal habitats are considered important nursery areas for a diverse range of fish species, such as emperor (*Lethrinidae*), threadfin bream (*Nemipteridae*), tuskfish (*Labridae*) and trevally (*Carangidae*) (de Lestang & Jankowski 2017).

Ramsar wetlands within the area (e.g. Eighty Mile Beach and Ashmore Reef National Nature Reserve) can also provide important habitat for fish (see **Section** Error! Reference source not found.).

5.1.6 Central Western Transition

The biological communities of the Central Western Transition are thought to be distinctive owing to the proximity of deep oceans areas to the continental slope and shelf, resulting in close interaction between pelagic species of the Cuvier Abyssal Plain and those of the slope and shelf (DEWHA 2008a).

The present level of understanding of the marine environment in this bioregion is generally poor. The diversity of fish and cephalopod species changes with depth, generally decreasing species numbers with increasing depth. The demersal slope fish bioregionalisation identified some endemism in communities in this bioregion (Last *et al*. 2005), however, it is lower than other areas of the North-west Marine Region (DEWHA 2008a).

Bentho-pelagic fish, such as deep-water snappers (e.g. *Paracaesio* spp, and *Eletis* spp.), hatchetfish (*Argyropelecus* spp.), dragonfish (*Melacosteus* spp.), viperfish (*Chauliodus* spp.) and a number of eels species migrate between the benthic and pelagic systems, forming an important link between these systems (DEWHA 2008a).

Transient fish species through the Central Western Transition bioregion include southern bluefin tuna (migrating to and from spawning grounds), broadbill swordfish (*Xiphius gladius*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and striped marlin (*Tetrapturus audax*). Pelagic sharks also range across the bioregion following schools of pelagic fish (DEWHA 2008a).

5.1.7 Northwest Shelf Province and Northwest Province

The demersal zone of the North West Shelf (which includes the Northwest Province and Northwest Shelf Province) hosts a diverse assemblage of fish of tropical Indo-west Pacific affinity, with up to 1,400 species known to occur, with a great proportion of these occurring in shallow coastal waters (Allen *et al*. 1988). Last *et al*. (2005) and Fox and Beckley (2005) described the North-west Province as being characterised by a high level of endemism and species diversity. Certain areas of increased biological activity (e.g. Glomar Shoals) attract demersal fish species such as Rankin cod, red emperor, crimson snapper and spangled emperor that are exploited by commercial trawl and trap fisheries (Sainsbury *et al*. 1992, Fletcher and Santoro 2013).

The shallow waters (<30 m) of the Dampier Archipelago, in the Northwest Shelf Province, support a characteristic and rich fish fauna of 650 species from a variety of habitats including coral and rocky reefs, mangroves, sand and silty bottoms and sponge gardens (Hutchins 2003 & 2004). The majority of these species are found over hard substrate, but significant numbers are also found from soft bottom and mangrove areas. The outer islands of the Archipelago are inhabited predominantly by coral reef fishes whereas inner areas close to the mainland are occupied by mangrove and silty-bottom dwellers. The inter-island passages have a relatively rich soft bottom fauna. EPBC Act protected fish species within the Dampier Archipelago include the dwarf sawfish (*Pristis clavata*), freshwater sawfish (*Pristis pristis*) and narrow sawfish (*Anoxypristis cuspidate*).

The fish fauna of the archipelago is less diverse than the islands of the West Pilbara to the south, but are closely related to the fauna at the offshore Montebello Islands (Hutchins 2004). The fish fauna of Barrow/ Lowendal/ Montebello Islands are widespread throughout the Indo-west Pacific region.

Within the southern portion of the Northwest and Northwest Shelf Province, small pelagic fish (e.g. lantern fishes) comprise a third of the total fish biomass (Bulman 2006) and inhabit a range of marine environments, including inshore and continental shelf waters. These small pelagic fish play an important ecological role, not only for this particular area but for the entire NWMR. They feed on pelagic phytoplankton and zooplankton and provide a food source for a wide variety of predators such as marine mammals, sharks, large pelagic fish and seabirds, thus providing a vital link between many of the region's trophic systems (Mackie *et al*. 2007).

Pelagic fish in the Northwest and Northwest Shelf Province include tuna, mackerel, herring, pilchard and sardine, and game fish such as marlin and sailfish (BBG 1994, Brewer *et al*. 2007), some of which are targeted by both commercial and recreational fishers. In particular, adult and juvenile southern bluefin tuna are thought to migrate through the North West Shelf on their way to and from spawning grounds in the north-eastern Indian Ocean. However, the timing of these migrations and the use of regional currents to assist their migration is still unclear. The oceanic waters of the North West Shelf are also believed to provide important spawning and nursery grounds for a number of large pelagic fish species. **Table 5-2** provides a summary of the key fish species and likely timing of their spawning in the region (DoF correspondence).

5.1.8 Northwest Shelf Transition

Creek systems, mangroves and rivers, and ocean beaches within this region provide habitat for a variety of species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin and cods (Fletcher and Santoro 2013). The offshore atolls and the continental shelf waters in the Northwest Shelf Transition are also geographically important for fish species. They support species of recreational and commercial interest, including saddle-tail snapper and red emperor, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish (DEC 2009).

The Rowley Shoals within the Northwest Shelf Transition comprise three oceanic reef systems approximately 30–40 km apart, namely Mermaid Reef, Clerke Reef and Imperieuse Reef. The Shoals are thought to provide a source of invertebrate and fish recruits for reefs further south and as such are regionally significant (DEC 2007b). See **Section 10.1.18** on State Marine Parks and Nature Reserves for further details on important geographical areas for fish.

5.1.9 Northwest Transition

The Northwest Transition bioregion may support sparse populations of bentho-pelagic fish and cephalopods in low densities. Pelagic fish species likely to be present include grenadiers and hatchetfish (*Argyropelecus* spp.) as well as transient populations of highly mobile pelagic fish. Adult and juvenile southern bluefin tuna are through to migrate through this bioregion on their way to and from spawning grounds in the north-eastern Indian Ocean (DEWHA 2008a).

The slope habitat of this bioregion is associated with important populations of demersal fish species and supports the second richest demersal fish assemblage nationally (Last *et al*. 2005). Over 508 fish species have been identified on the slope in this area and 64 of these species are endemic. The high diversity and endemism of the demersal fish fauna indicates important interactions between physical processes and trophic structures in this bioregion. For more information on the slope habitat for fish and sharks, refer to **Section** Error! Reference source not found..

The Rowley Shoals within the Northwest Transition comprise three oceanic reef systems approximately 30–40 km apart, namely Mermaid Reef, Clerke Reef and Imperieuse Reef. The Shoals are thought to provide a source of invertebrate and fish recruits for reefs further south and as such are regionally significant (DEC 2007b).

5.1.10 Timor Province

The diversity of demersal fish assemblages on the continental slope in the Timor Province (as well as the Northwest Transition and the Northwest Province) is high compared to elsewhere along the Australian continental slope (DEC 2009). Elements of the Timor Province are not well known, due to limited survey data in the northern limits of the region. The province is geographically extensive and includes 418 fish species, 64 of which are endemic to the region (Last *et al.* 2009). Key indicator species include *Bembrops nelsoni*, *Bythaelurus* sp., *Halicmetus* sp., *Malthopsis* spp, *Neobythites australiensis*, *Nobythites bimaculatus*, *Neobythites macrops*, *Neobythites soelae*, *Parapterygotrigla* sp., *Physiculus roseus* (Last *et al.* 2005).

Scott and Seringapatam Reefs are regionally important for the diversity of their fauna, including 558 fish species (Department of the Environment (DoE) 2014). Scott Reef has enormous habitat diversity and is considered a hot spot for fish, with five endemic species (DoE 2014). Scott Reef has biogeographic significance due to the presence of species which are at or close to the limits of their geographic ranges, including fish known previously only from Indonesian waters such as cardinalfish, azure damselfish (*Chrysoptera hemicyanea*), comb-tooth blenny (*Escnius schroederi*) and several Gobiids (DoE 2014).

The diversity of fish at Ashmore Reef is also higher than other comparable reefs in the bioregion with over 760 species recorded (Russell *et al.* 2005, Kospartov *et al.* 2006. The majority of fish species are shallow water, benthic taxa that typically inhabit depths down to 100 m and are widely distributed throughout the Indo-West Pacific (Russell *et al.* 2005). The most species rich groups are gobies (*Gobiidae*), damselfishes (*Pomacentridae*), wrasses (*Labridae*), cardinal fishes (*Apogonidae*), moray eels (*Muraenidae*), butterflyfishes (*Chaetodontidae*), and rockcods and groupers (*Serranidae*) (Allen 1993, Russell *et al*. 2005).

5.1.11 Christmas Island Province

The Christmas Island Province is in deep, offshore waters (2,200 m – 6,000 m depth range). These waters provide habitat for pelagic finfish species including tuna (*Thunnus* sp.) and wahoo (*Acanthocybium solandri*), and some demersal species such as ruby snapper (*Etelis carbunculus*). (Director of National Parks 2014)

Table 5-2: Spawning and aggregation times of key commercially caught fish species within the North West Shelf

Species		Month											
Species Common Name	**Species Latin Name**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Blacktip shark	*Carcharhinus tilstoni* and *C. limbatus*												
Goldband snapper	*Pristipomoides multidens*												
Rankin cod	*Epinephelus multinotatus*												
Red emperor	*Lutjanus sebae*												
Sandbar shark	*Carcharhinus plumbeus*												
Spanish mackerel	*Scomberomorus commerson*												
Pink snapper	*Pagrus auratus*												
Baldchin groper	*Choerodon rubescens*												
Crystal (snow) crab	*Chaceon spp*												
King George whiting	*Sillaginodes punctate*												
Spangled emperor	*Lethrinus Nebulosus*												

5.2 Fish Species

Three species of fish listed as threatened under the EPBC Act (**Table 5-1**) were identified in the Protected Matters search for the EMBA:

- Balston's pygmy perch (*Nannatherina balstoni*);
- Blind gudgeon (*Milyeringa veritas*); and
- Blind cave eel (Ophisternon candidum).

In addition the Barrow cave gudgeon *(Milyeringa justitia*) has been identified as relevant threatened species under the *Biodiversity Conservation Act 2016*. This species is not listed under the EPBC Act.

5.2.1 Blind Gudgeon, Balston's Pygmy Perch and Blind Cave Eel

Both the blind gudgeon (*Milyeringa veritas*) and blind cave eel (*Ophisternon candidum*) are known to occur on the Cape Range Peninsula (in the Central Western Shelf Transition) (Humphreys and Feinberg 1995), and a related species of the genus Milyeringa, the Barrow cave gudgeon *(Milyeringa justitia*) has also been noted at Barrow Island (Humphreys 1999). The Barrow cave gudgeon is listed as Vulnerable under the WA Biodiversity Conservation Act 2016. They have been recorded in waters ranging from fresh to seawater at depths of up to 33 m in caves and 50 m in wells and bores. Both species are restricted to either caves or groundwater (Humphreys and Blyth 1994) and are the only two vertebrate animals known from Australia for this (DoE 2014a). The Balston's pygmy perch distribution ranges from Moore River (75 km north of Perth) at the northern extent to Two Peoples Bay near Albany. This freshwater species is typically associated with shallow waters near riparian vegetation and is considered to have low salinity tolerance, making it unlikely to occur in estuarine conditions (DoEE, 2016).

5.2.2 Syngnathids

The EPBC Protected Matters search also identified 72 ‘listed marine species of fish which are largely from the family Syngnathidae. Syngnathids are a group of bony fishes that include seahorses, pipefishes, pipehorses and sea dragons, although taxonomic uncertainty still surrounds a number of these (DEWHA 2012a). Knowledge about the distribution, abundance and ecology of syngnathids is limited.

5.3 Sharks, Rays and Sawfishes

The diversity of marine environments in the waters within both the NWMR and SWMR have led to a rich fauna of cartilaginous fish (sharks and rays). Of the approximately 500 shark species found worldwide, 19% (94) are found in the region (DEWHA 2008a). The EPBC Act Protected Matters search for the EMBA identified four species of shark, and three species of sawfishes listed as threatened within the search area between south west WA and NT border (**Table 5-1**), including:

+ Grey nurse shark (*Carcharias taurus*);
+ Great white shark (*Carcharodon carcharias*);
+ Northern river shark (*Glyphis garricki*);
+ Whale shark (*Rhincodon typus*);
+ Dwarf sawfish (*Pristis clavata*);
+ Freshwater sawfish (*Pristis pristis*); and
+ Green sawfish (*Pristis zijsron*).

In addition, the narrow sawfish (*Anoxypristis cuspidate*), two species of ray, the reef manta ray (*Manta alfredi*) and giant manta ray (*Manta birostris*), the portbeagle (*Lamna nasus*) and the longfin (*Isurus paucus*) and shortfin (*Isurus oxyrinchus*) mako sharks are listed as migratory within the search area (**Table 5-1).**

The biologically important areas (BIAs) for the whale shark is shown below in **Figure 5-1.**

5.3.1 Grey Nurse Shark

The grey nurse shark (*Carcharias taurus*) is listed as vulnerable under the EPBC Act and the *Biodiversity Conservation Act 2016* and may be found within the EMBA. In Australia, the grey nurse shark is now restricted to two populations, one on the east coast from southern Queensland to southern NSW and the other is predominantly found around the southwest coast of WA, but has been recorded on the North West Shelf (DEWHA 2012b, Pogonoski *et al*. 2002). It is believed that the east and west coast populations do not interact and ongoing research will probably confirm that the populations are genetically different (Last and Stevens 2009).

While it is thought that grey nurse sharks have a high degree of site fidelity, some studies (McAuley 2004) suggest that grey nurse sharks move between different habitats and localities, exhibiting some migratory characteristics. In certain areas grey nurse sharks are vulnerable to localised pressure due to high endemism. The status of the west coast population is poorly understood although they are reported to remain widely distributed along the WA coast and are still regularly encountered, albeit with low and indeterminate frequency (Chidlow *et al*. 2006).

Grey nurse sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and in the vicinity of inshore rocky reefs and islands (Pollard *et al*. 1996). The species has been recorded at varying depths, but is generally found between 15–40 m (Otway & Parker 2000). Grey nurse sharks have also been recorded in the surf zone, around coral reefs, and to depths of around 200 m on the continental shelf (Pollard *et al*. 1996). Grey nurse sharks feed primarily on a variety of teleost and elasmobranch fishes and some cephalopods (Gelsleichter *et al*. 1999, Smale 2005).

5.3.2 Great White Shark (White Shark)

The great white shark (*Carcharodon carcharias*) is listed as vulnerable and migratory under the EPBC Act and is listed as vulnerable under the *Biodiversity Conservation Act 2016* . In Australia, great white sharks have been recorded from central Queensland around the south coast to northwest WA, but may occur further north on both coasts (Last and Stevens 2009). There are no known aggregation sites for white sharks in the North-west marine region, but the species has been recorded in NWS waters during humpback migrations (DEWHA 2012b). They are widely but not evenly distributed in Australian waters and are considered uncommon to rare compared to most other large sharks (CITES 2004).

Study into great white shark populations is difficult (Cailliet 1996) given the uncertainty about their movements, emigration, immigration and difficulty in estimating the rates of natural or fishing mortality.

Great white sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski *et al*. 2002). They also make open ocean excursions and can cross ocean basins (for instance from South Africa to the western coast of Australia and from the eastern coast of Australia to New Zealand). Great white sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA 2009). The relevant great white shark BIAs in the EMBA are detailed in **Table 5-3**.

A BIA for great white shark were identified in the EMBA.

5.3.3 Northern River Shark

The northern river shark (*Glyphis garricki*) is listed as Endangered under the EPBC Act and is one of the rarest species of shark in the world. Adults only recorded in marine habitats, whereas neonates, juveniles and subadults recorded in freshwater, estuarine and marine environments. It is also listed as a Priority 1 conservation species in WA.

The associated recovery plan (Sawfish and River Sharks Multispecies Recovery Plan, Commonwealth of Australia 2015) identifies adults and juveniles are being known in WA marine waters north of Derby. Pupping and juvenile sharks are identified as known to occur in Cambridge Gulf and pupping is also identified as likely to occur in King Sound. Under the associated recovery plan all areas where aggregations of individuals have been recorded displaying biologically important behaviours such as breeding, foraging, resting or migrating are considered critical to the survival of the species unless population data suggests otherwise.

5.3.4 Whale Shark

The whale shark (*Rhincodon typus*) is listed as vulnerable and migratory under the EPBC Act and is also listed as a specially protected species under the *Biodiversity Conservation Act 2016* as a species of special conservation interest (conservation dependent fauna). The species is also classified as vulnerable on the World Conservation Union's Red List of Threatened Species (Norman 2005) and are protected under the WA *Conservation and Land Management Act 1984* and WA *Fish Resources Management Act 1994*.

The whale shark is the largest of all fish (>18 m; Borrell *et al*. 2011; Chen *et al*. 1997, Compagno 2001) and is a migratory species with worldwide geographical ranges between 30º N and 35º S (Last and Stevens 2009). There is a general lack of knowledge on many aspects of whale shark biology, including definitive migration patterns. The species is oceanic but often forms aggregations in coastal waters at sites throughout the tropics. Typically, these aggregations are seasonal and often coincide with specific productivity events that are a focus of feeding for the animals. For example, whale sharks aggregate to feed on dense swarms of copepods in Baja California (Clarke and Nelson 1997), fish spawn off Belize (Heyman *et al*. 2001) and red crab larvae at Christmas Island (Meekan *et al*. 2009).

One of the best known aggregation sites for whale sharks occurs along the central and NW coast of Western Australia from March to July and is focused at Ningaloo Reef, within the Exmouth region. The small size and general absence of female whale sharks from Ningaloo Reef suggests that the region may be important for feeding rather than breeding (Norman and Stevens 2007). The timing of this aggregation coincides with a pulse in seasonal productivity that results in large abundances of tropical krill on which these filter feeding sharks feed (Meekan *et al*. unpublished data, Jarman and Wilson 2004). At Ningaloo Reef, whale sharks are often found swimming close to the reef front, within a few kilometres of the shore and in water of less than 50 m deep. A tourist industry based on snorkelling with the sharks in this area has developed over the last 15 years and is now estimated to be worth over $4 million annually to the local economy of the Ningaloo region.

Estimates of the size of the population participating in the Ningaloo aggregation are between 300 and 500 individuals (Meekan *et al*. 2006), but research indicates that the Ningaloo population of whale sharks is declining (Bradshaw *et al*. 2007).

Whale sharks are known to be highly migratory with migrations of 13,000 km being recorded (Eckert and Stewart 2001). Research on the migration patterns of whale sharks in the western Indian Ocean, and isolated and infrequent observations of individuals, indicate that a small number of the Western Australian population migrate through the North West Shelf. Wilson *et al*. (2006) tagged 19 whale sharks in 2003 and 2004, with long term movements patterns successfully recorded from six individuals. All travelled northeast into the Indian Ocean after departing Ningaloo Reef, with one tracked to Ashmore Reef and another to Scott Reef. Whale sharks are occasionally observed from Santos WA's offshore oil and gas facilities on the North West Shelf (Harriet Alpha and Stag platforms). In general, migration along the northern WA coastline broadly follows the 200 m isobath and typically occurs between July and November (DoE 2015).

A biologically important area for whale sharks is located in northern WA, offshore of the Pilbara and Kimberley coastline, and broadly follows the 200 m isobath. The relevant whale shark BIAs in the EMBA are detailed in **Table 5-3** and is shown on **Figure 5-1**. A whale shark foraging BIA is in close proximity to the operational area and a BIA for aggregation events off the Ningaloo coast, approximately 25 km from the operational area is within the EMBA.

DBCA has a wildlife management program to manage whale shark interactions in reserves - *Whale shark management with particular reference to Ningaloo Marine Park, Wildlife Management Program no. 57 (2013).*

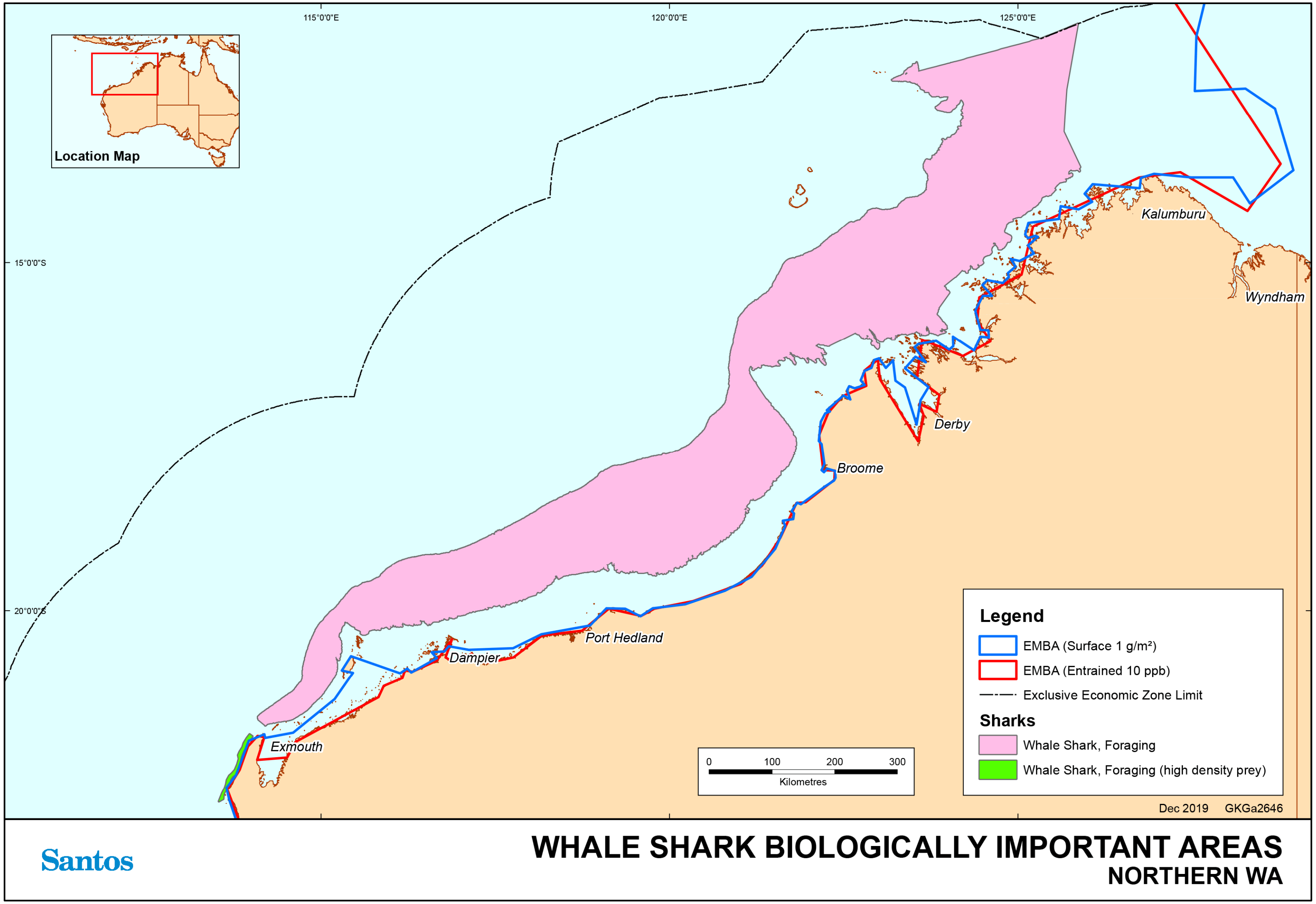

Figure 5-1: Biologically important area – whale shark

5.3.5 Dwarf Sawfish

The dwarf sawfish (*Pristis clavata*) is listed as vulnerable under the EPBC Act and thought to be restricted to Australia (DoE 2014b). It is also listed as a Priority 1 conservation species in WA. The Australian distribution of the dwarf sawfish is considered to extend across northern Australia and along the Kimberley and Pilbara coasts (Last and Stevens 2009, Stevens *et al*. 2005). However, the majority of records of dwarf sawfish in WA have come from shallow estuarine waters of the Kimberley region which are believed to be nursery (pupping) areas, with immature juveniles remaining in these areas up until three years of age (Thorburn *et al*. 2004). Adults are known to seasonally migrate back into inshore waters (Peverell 2007); although it is unclear how far offshore the adults travel as captures in offshore surveys are very uncommon. The species' range is restricted to brackish and salt water (Thorburn *et al*. 2007).

The recovery plan identifies pupping as known to occur in the King Sound, the Cambridge Gulf and 80 Mile Beach, with pupping likely to occur identified at a number of locations along the Pilbara and Kimberly Plan (DoEE 2015). Under the associated recovery plan all areas where aggregations of individuals have been recorded displaying biologically important behaviours such as breeding, foraging, resting or migrating are considered critical to the survival of the species unless population data suggests otherwise.

5.3.6 Freshwater and Green Sawfish

The freshwater sawfish (*Pristis pristis)* and green sawfish (*Pristis zijsron)* are both listed as Vulnerable under the EPBC Act. The freshwater sawfish is listed as a Priority 1 conservation species in WA, while the green sawfish is listed as Vulnerable under the *Biodiversity Conservation Act 2016.*

Both species are wider-ranging than the dwarf sawfish and are also found in the Indo-west Pacific (DoE 2014c, DoE 2014d). Important areas for sawfishes include King Sound, and the Fitzroy, Durack, Robinson and Ord rivers for the freshwater sawfish; and Cape Keraudren for the green sawfish (Stevens *et al*. 2008, Thorburn *et al*. 2007, 2008).

Sawfishes generally inhabit inshore coastal, estuarine and riverine environments. The freshwater sawfish has been recorded in north-west Australia from rivers (including isolated water holes), estuaries and marine environments (Stevens *et al*. 2005). Newborns and juveniles primarily occur in the freshwater reaches of rivers and in estuaries, while most adult freshwater sawfish have been recorded in marine and estuarine environments (Peverell 2005, Thorburn *et al*. 2007). It is believed that mature freshwater sawfish enter less saline waters during the wet season to give birth (Peverell 2005) and freshwater river reaches play an important role as nursery areas (DoE 2014c).

The green sawfish has predominantly been recorded in inshore coastal areas, including estuaries and river mouths with a soft substrate, although there have been records of sawfish offshore in depths up to 70 m (Stevens *et al*. 2005). This species does not occupy freshwater habitats (DoE 2014d).

Short-term tracking has shown that green sawfish appear to have limited movements that are tidally influenced, and they are likely to occupy a restricted range of only a few square kilometres within the coastal fringe, with a strong association with mangroves and adjacent mudflats (Stevens et al. 2008). Sawfishes feed close to the benthos on a variety of teleost fishes and benthic invertebrates, including cephalopods, crustaceans and molluscs (Compagno & Last 1999, Last & Stevens 2009, Pogonoski *et al*. 2002, Thorburn *et al*. 2007, 2008).

5.3.7 Narrow Sawfish

The narrow sawfish (*Anoxypristis cuspidate*) is listed as Migratory under the EPBC Act. It is a marine or marginal (brackish water) species found from inshore waters to a depth of 40 m (Compagno *et al.* 2006). Though details of its ecology are not precisely known, it probably spends most of its time on or near the bottom in shallow coastal waters and estuaries. A study showed the narrow sawfish to be the most abundant amongst the sawfish sampled in the Gulf of Carpentaria (Peverell 2005) which holds some consistency with the offshore distribution of the species as shown by a study of Northern Prawn Fishery by-catch. Peverell (2005) also used catch data of offshore surface net fisheries to conclude that narrow sawfish also inhabit the mid-water column and can thus be described as a benthopelagic animal. The narrow sawfish is known to form aggregations of mature females during the months of October to November. Its Australian distribution is unclear though it is most common in the Gulf of Carpentaria with southward ranges extending to Broad Sound in Queensland and the Pilbara Coast (circa 116°E), Western Australia (Last & Stevens 2009).

5.3.8 Giant Manta Ray / Reef Manta Ray

The giant manta ray appears to be a seasonal visitor to coastal or offshore sites. Giant manta rays are often seen aggregating in large numbers to feed, mate, or clean. Sightings of these giant rays are often seasonal or sporadic but in a few locations their presence is a more common occurrence. This species is not regularly encountered in large numbers and, unlike some other rays do not often appear in large schools (>30 individuals) when feeding. Overall, they are encountered with far less frequency than the smaller manta species, despite having a larger distribution across the globe (IUCN, 2014b).

The giant manta ray occurs in tropical, sub-tropical and temperate waters of the Atlantic, Pacific and Indian Oceans. They are commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts. The giant manta ray is commonly encountered on shallow reefs while being cleaned or is sighted feeding at the surface inshore and offshore. It is also occasionally observed in sandy bottom areas and seagrass beds (IUCN, 2014b).

The Reef manta ray has a circumtropical and sub-tropical distribution, existing in the Pacific, Atlantic and Indian Oceans. Within this broad range, however, actual populations appear to be sparsely distributed and highly fragmented. This is likely due to the specific resource and habitat needs of this species.

Overall population size is unknown, but subpopulations appear, in most cases, to be small (about 100–2,000 individuals). A proportion of the individuals in some populations undertake significant coastal migrations (IUCN, 2016). Since the species is migratory it is possible that individuals may be encountered in the operational area, however, given that they generally don't aggregate in large groups, high numbers are not expected to be encountered during the activities.

5.3.9 Shortfin Mako and Longfin Mako Sharks

The shortfin mako and longfin mako sharks are listed as Migratory under the EPBC Act. The longfin mako is widely distributed but rarely encountered oceanic shark that ranges from Geraldton around the north coast to at least Port Stephens in New South Wales (DSEWPaC, 2012). The shortfin mako is an oceanic and pelagic species, although they are occasionally seen inshore. They are found throughout temperate seas but are rarely found in waters colder than 16°C.

5.3.10 Porbeagle (Mackerel Shark)

The porbeagle (mackerel shark) (*Lamna nasus*) are listed as Migratory under the EPBC Act. The porbeagle is wide-ranging, typically occurring in oceanic waters off the continental shelf, although they occasionally enter coastal waters (Francis *et al*. 2002 cited in DoE 2014e). The porbeagle is known to undertake seasonal migrations, although the timing and details of these migratory movements are not well understood (Saunders *et al.* 2011 cited in DoE 2014e).

5.4 Biologically Important Areas / Critical Habitat – Fish

BIAs are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration**.** BIAs are identified by DoAWE however, they have no legal status, but are designed to assist decision making under the EPBC Act. They are not designed to identify protected areas, but may inform such processes. **Table 5-3** below provides an overview of BIAs in the EMBA for fish.

The DoAWE may make recovery plans for threatened fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, and summary of relevant recovery plans is listed in **Section 13.2**. BIAs may overlap these sites, but may be identified for other purposes. DoAWE state that the criteria used to identify 'habitat critical to the survival of the species' are more complex than those used it identify BIA. Specifically, the Sawfish and River Sharks Multispecies Recovery Plan (DoEE 2015) cites that *"all areas where aggregations of individuals have been recorded displaying biologically important behaviour such as breeding, foraging, resting or migrating, are considered critical to the survival of the species unless population survey data suggests otherwise"*.

In addition, both the EPBC Act and WA *Biodiversity Conservation Act 2016* and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species'. To date no critical habitat in WA has been listed under either Act.

Refer to Section 3 of the Ningaloo Vision Operations EP for species' BIAs within the EMBA, PW mixing zone and operational area.

Table 5-3: Biologically important areas - fish

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Great white shark	*Carcharodon carcharias*	Foraging – associated with pinniped colonies in the mid-west and south west and waters off Bremer Bay	Waters off pinniped colonies throughout the South-west Marine Region Waters off Bremer Bay
Whale shark	*Rhincodon typus*	Foraging (high density prey) – Ningaloo Reef Foraging – Wider Ningaloo Region	Ningaloo Marine Park and adjacent Commonwealth waters Northward from Ningaloo along 200 m isobath

6. Marine Reptiles

Twenty eight species of listed marine reptiles under the Commonwealth *EPBC Act 1999* are known to occur in Australian waters in the EMBA, Five of these occur within the operational area according to the Protected Matters searches.

An examination of the species profile and threats database (DoEE 2019) showed that some listed reptile species are not expected to occur in significant numbers in the marine and coastal environments in the EMBA due to their terrestrial distributions. Hence, these species are not discussed further.

Of the remaining reptile species identified in the Protected Matters search, seven are listed as threatened and five are listed as migratory. These species are show in **Table 6-1** along with their WA conservation listing (as applicable)[3]. BIAs within the EMBA area discussed in **Table 6-3**. No BIAs overlap the operational area. The operational area is 7 km from an internesting habitat critical to the survival of flatback turtles, which is also designated a BIA.

Table 6-1: EPBC listed marine reptile species in the EMBA

Species	Conservation Status			Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016*	Other WA Conservation Code		
Green turtle (*Chelonia mydas*)	Vulnerable Migratory	Vulnerable	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Flatback turtle (*Natator depressus*)	Vulnerable Migratory	Vulnerable	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable Migratory	Vulnerable	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Loggerhead turtle (*Caretta caretta*)	Endangered Migratory	Endangered	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered Migratory	Endangered	-	Foraging feeding or related behaviour known to occur within area	No – BIA not within EMBA
Leatherback turtle (*Dermochelys coriacea*)	Endangered Migratory	Vulnerable	-	Foraging feeding or related behaviour known to occur within area	No-BIA not within EMBA
Short-nosed seasnake (*Aipysurus apraefrontalis*)	Critically Endangered	Critically Endangered	-	Species or species habitat known to occur within area	None - No BIA defined

[3] An overview of WA fauna conservation codes is provided in **Section 5** (fish and sharks).

6.1 Marine Turtles

Six species of marine turtle occur in, use the waters, and nest on sandy beaches in WA. These are the green turtle (*Chelonia mydas*), flatback turtle (*Natator depressus*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), Olive Ridley turtle (*Lepidochelys olivacea)* and leatherback turtle (*Dermochelys coriacea*) (**Table 6-1**).

These six species are listed on the EPBC Act List of Threatened Species as either 'endangered' or 'vulnerable' and all six species are also listed as 'migratory'. They are also listed as threatened species under the *Biodiversity Conservation Act 2016.*

A summary of the different habitat types used during the various life stages of marine turtle species identified in the EMBA is given in **Table 6-2.**

Table 6-2: Summary of habitat types for the life stages of the six marine turtle species in the EMBA (DSEWPaC, 2012b)

Life Stage		Green turtle	Flatback turtle	Hawksbill turtle	Loggerhead turtle	Olive Ridley turtle	Leatherback turtle
Post-hatchling		Open ocean pelagic habitats (poorly studied for Australian populations)	Coastal waters (poorly studied for Australian populations)	Open ocean pelagic habitats (poorly studied for Australian populations)	Pelagic (poorly studied for Australian populations)	Pelagic (poorly studied for Australian populations)	Pelagic (no data for Australian populations)
Adult	Mating	Offshore from nesting beaches.	Currently unknown for North West Shelf region.	Offshore from nesting beaches.	Little is known for North West Shelf region but expected to occur either en-route or adjacent to nesting beaches.	Little is known for North West Shelf region but expected to occur either en-route or adjacent to nesting beaches.	Not recorded within North West Shelf region.
	Nesting	Typically, high energy, steeply sloped beaches with deep sand and deep water approach.	Typically, low-energy beaches that are narrow with a low to moderate slope. Beach approach obstructed by broad intertidal mud or limestone platforms.	Typically beaches close to nearshore coral reefs and sediment comprised of coarse sand and coral rubble.	Poorly studied for North West Shelf region by generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches.	Poorly studied for North West Shelf region by generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches.	Not recorded within North West Shelf region.
	Internesting	Shallow coastal waters within several kms of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats	Shallow nearshore waters within 5-60 km of nesting beach. Inter-nesting buffers of 40-60 km identified around all nesting habitats	Shallow coastal waters within several kms of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats	Shallow coastal waters within several kms of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats	Shallow coastal waters within several kms of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats	Not recorded within North West Shelf region.
	Foraging	Neritic habitats associated with seagrass and algae, and mangrove habitats.	Turbid, shallow inshore waters, subtidal, soft-bottomed habitats of the continental shelf.	Subtidal and intertidal coral and rocky reef habitats of the continental shelf.	Subtidal and intertidal coral and rocky reefs, seagrass and deeper soft-bottomed habitats of the continental shelf.	Subtidal and intertidal coral and rocky reefs, seagrass and deeper soft-bottomed habitats of the continental shelf.	Mostly pelagic but will forage close to shore and over continental shelf in temperate waters.

6.1.1 Loggerhead Turtle

The loggerhead turtle (*Caretta caretta*) has a worldwide distribution, living and breeding in subtropical to tropical locations (Limpus 2008b). Breeding aggregations in Australia occur on both the east coast (Queensland and NSW) and the west. The annual nesting population in Western Australia is thought to be 3,000 females annually (Baldwin *et al*. 2003), and this is considered to support the third largest population in the world (Limpus 2008b).

The WA distribution of sandy beach nesting areas extends from Shark Bay to the southern area of the NWS, with occasional late summer nesting crawls recorded as far north as Barrow and Varanus Island and the Lowendal and Rosemary Islands (DSEWPaC 2012d). Major nesting locations include the Muiron Islands, the Ningaloo Coast south to Carnarvon and the islands around Shark Bay, which includes Dirk Hartog Island, one of the principal nesting and inter-nesting sites in WA (Limpus 2008b). The Recovery Plan for Marine Turtles in Australia (2017) identifies the Muiron Islands (as a principal rookery), and all waters within a 20 km radius as habitat critical to the survival of loggerhead turtles.

Estimates of up to 5,000 female loggerhead turtles have been predicted within the Ningaloo Marine Park and Muiron Islands Marine Management Area (Waayers 2010). Earlier surveys found higher proportions of nesting loggerheads in the southern areas of the reserves (CALM 2005a). Aerial surveys conducted in 2000 and 2001 in the Exmouth region recorded only 12 sightings in Commonwealth waters and these turtles were most likely loggerheads (BHP 2005). In a survey commissioned by Santos WA around the islands in the Exmouth Region, loggerhead turtles were recorded nesting on Flat Island north of the Exmouth Gulf which was the first time they had been recorded in that location (Astron 2014).

Loggerhead nesting and breeding occurs from November to March, with a peak in late December/ early January (Limpus 2008b). However, there is variability each year as illustrated in a study by Santos WA (Astron 2014) around the islands in the Exmouth Region where higher numbers of nesting turtles were recorded in October 2013 than in the subsequent January 2014 surveys.

Foraging areas are widespread for loggerhead turtle populations and migrations from nesting to feeding grounds can stretch thousands of kilometres, including feeding grounds as far north as the Java Sea of Indonesia for the WA population (Limpus 2008b). Shark Bay has been identified as a critical feeding habitat for loggerhead turtles (Environment Australia 2003). Loggerhead turtles are carnivorous and feed primarily on benthic invertebrates from depths of up to approximately 50 m to near shore tidal areas including areas of rocky and coral reef, muddy bays, sand flats, estuaries and seagrass meadows (Limpus 2008b).

Figure 6-1 illustrates the BIAs and critical habitats for loggerhead turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017). EMBA overlaps interesting and nesting BIA.

Loggerhead turtle nesting areas extend from Shark Bay (including on the mainland near Steep Point) to the North West Cape and Muiron Islands region. Occasional late summer nesting crawls have also been recorded as far north as Barrow Island and the Lowendal Islands. The most concentrated nesting presence is found on the northern Dirk Hartog Island Turtle Bay-Cape Levillain coast. There is widespread low to medium intensity nesting across Ningaloo Marine Park–North West Cape beaches, and secondary concentration at the nearby Muiron Islands.

Loggerhead turtles choose a wide variety of tidal and subtidal habitat as feeding areas including rocky and coral reefs, muddy bays, sand flats, estuaries and seagrass meadows (Limpus 2008b). Loggerheads are mid-water column planktonic feeders.

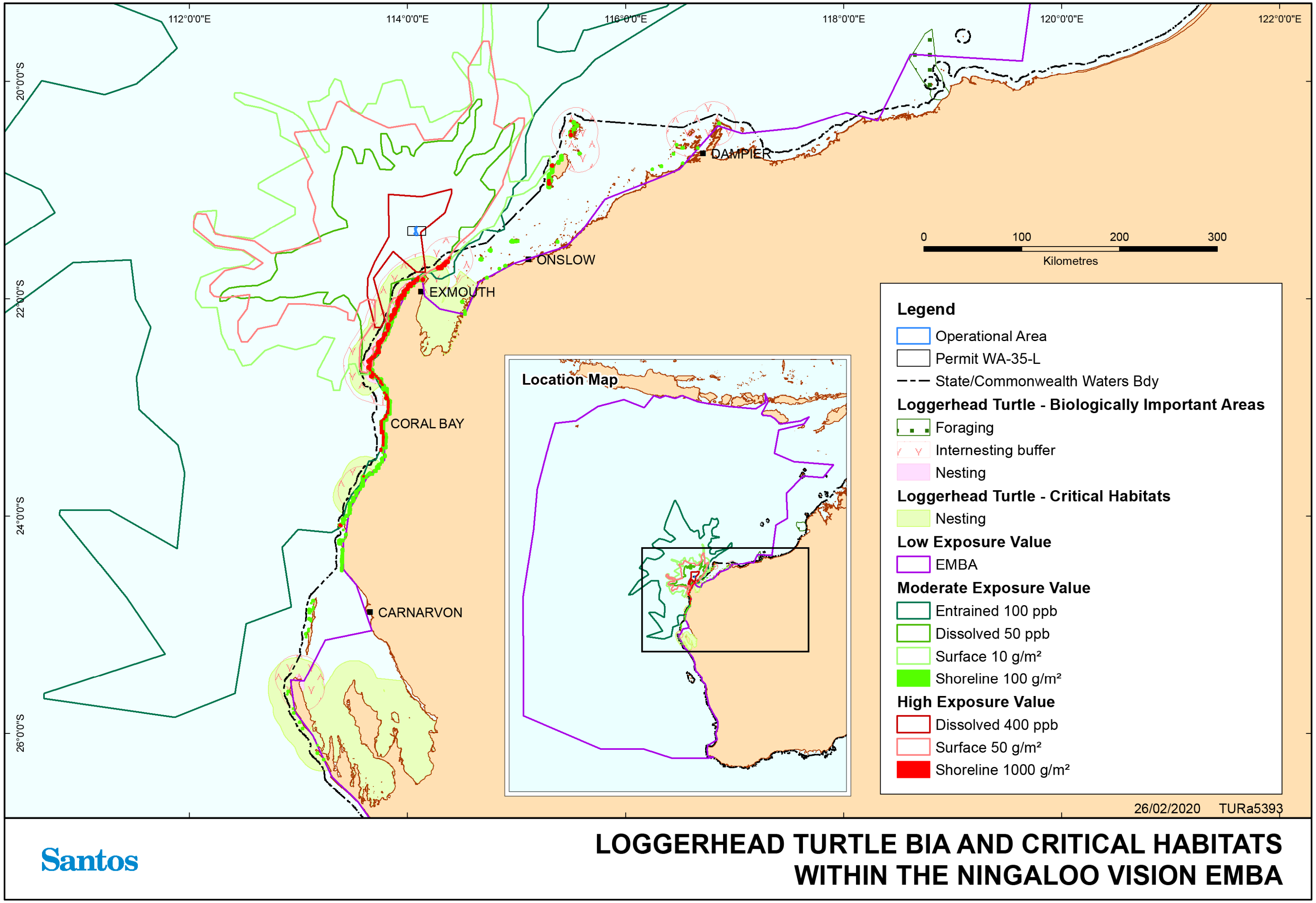

Figure 6-1: Biologically Important Areas and Critical Habitats – Loggerhead Turtle

6.1.2 Green Turtle

Australian population of green turtles is estimated to be approximately 70,000 and is divided into seven genetically distinct breeding aggregations. The species is widespread and abundant in WA waters with an estimated 20,000 individuals occurring, arguably the largest population in the Indian Ocean (Limpus 2008a). There are three distinct breeding stocks in western Australian waters which include: the North West Shelf (NWS) stock, the Scott Reef stock and the Ashmore Stock (Dethmers *et al*. 2006, Limpus 2008a).

The NWS population is one of the largest in the world and the most significant rookery is the western side of Barrow Island (Prince 1994, Limpus 2008a). Other principal rookeries include the Lacepede Islands, Montebello Islands, Dampier Archipelago, Browse Island and North West Cape (Prince 1994, Limpus 2008a, DSEWPaC 2012b). See **Table 6-3** for a complete list.

Surveys by Waayers (2010) within the Ningaloo Marine Park and Muiron Islands Marine Management Area estimated up to 7,500 female green turtles used these areas. In 2014, Santos WA commissioned a survey of the islands in the Exmouth Region which found that North and South Muiron Islands were significant nesting sites for green turtles with over 100 green turtles nesting overnight on one beach at North Muiron Island (Astron 2014). The green turtle is also known to breed in large numbers in the dunes above the extensive beaches found on Serrurier Island, with counts indicating the island supports the second largest rookery in the Pilbara (Oliver 1990).

Lower density green turtle nesting has also been recorded on Jurabi coast, Thevenard Island, Lowendal Islands and in Exmouth Gulf (Limpus 2008a). Only low numbers of green turtles have been observed nesting on Varanus Island, as well as Airlie Island (Pendoley Environmental 2011). From monitoring undertaken in 2016/17 by Santos WA on Varanus Island; three green turtles were observed to nest over a four week tagging effort (Astron 2017).

Green turtle nesting abundance and timing fluctuates significantly from year to year depending on environmental variables, locality and food availability (Pendoley Environmental 2011). Nesting of green turtles has been recorded from August to March on Serrurier Island (Woodside 2002), from December to March along coast adjacent to Ningaloo (CALM 2005a) and from October to February on Varanus Island (Pendoley Environmental 2011). On Barrow Island, mating aggregations may commence from October with peak nesting from December to January, with hatchlings emerging through summer and early autumn. However, nesting on Barrow Island has been recorded all year round (Chevron 2005 and 2008, Pendoley 2005). Nesting on the Scott Reef-Sandy Islet and Browse Island has been observed all year round with peaks between December and January (Commonwealth of Australia 2017). The re-nesting period for female green turtles is approximately five years (Hamann *et al*. 2002).

Green turtles spend the first five to ten years of their life drifting on ocean currents, before moving to reside in shallower benthic habitats, including tropical coral and rocky reefs and seagrass beds. Green turtles have been known to migrate more than 2600 km between feeding and breeding grounds (Limpus 2008a).

Green turtles are omnivores, mainly feeding in shallow benthic habitats on seagrass and/ or algae, but are also known to feed on sponges, jellyfish and mangroves (Limpus 2008a). Green turtles are unlikely to forage or dwell within deeper off shore waters due to the water depths; however, they may occasionally migrate through it.

Figure 6-2 illustrates the BIAs and critical habitats for green turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017). EMBA overlaps interesting, foraging, mating, nesting and aggregation BIA.

The green turtle is the most widespread and abundant turtle species in WA waters (Limpus 2002), nesting from the Ningaloo coast to the Kimberley islands (Prince 1994). Major nesting rookeries are found on the Lacepede Islands, Montebello Islands, Barrow Island, Lowendal Islands and Browse Island and Rosemary Island, as well as on the northeast coast of Legendre Island and the western and eastern shores of Delambre Island (Woodside 2005). A number of smaller nesting sites can also be found on the mainland between the Ningaloo and Kimberley coasts. Green turtle nesting abundance fluctuates significantly from year to year, depending on environmental variables and food availability at feeding sites. In an aerial survey of Pilbara waters in April 2000, Prince (2001) estimated a mixed species population of 57,000 turtles of which most were green turtles.

Green turtles are herbivores, feeding on shallow benthic habitats containing seagrass and/or algae including coral and rocky reefs, and inshore seagrass beds.

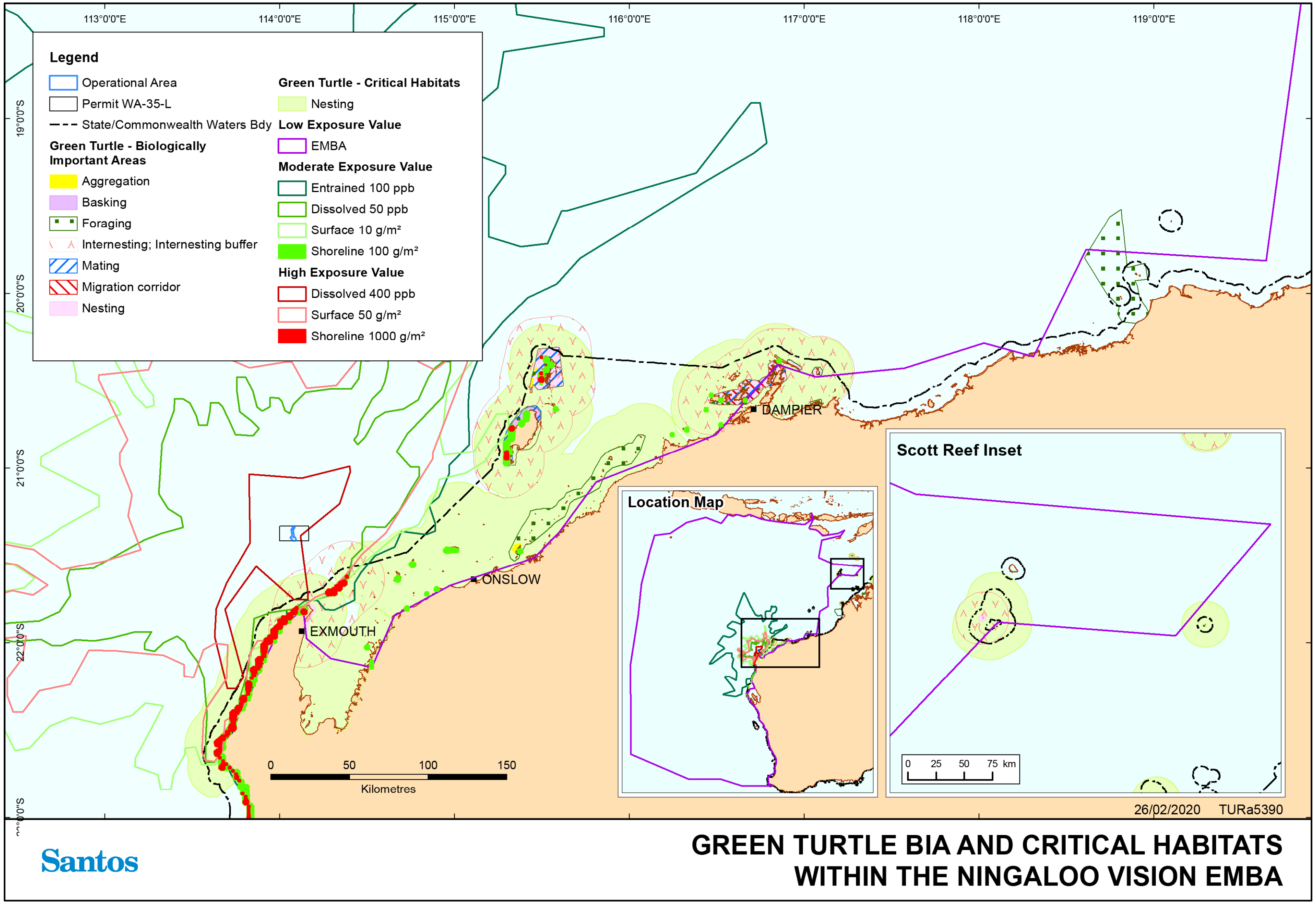

Figure 6-2: Biologically Important Areas and Critical Habitats – Green Turtle

6.1.3 Hawksbill Turtle

Hawksbill turtles (*Eretmochelys imbricata*) have a global distribution throughout tropical and sub-tropical marine waters. The Western Australian stock is concentrated on the NWS (Dampier Archipelago) (Limpus 2009a), and is considered to be one of the largest hawksbill populations remaining in the world. The estimated number of nesting hawksbill turtles in WA waters is between 2,000 and 4,500 individuals (Morris 2004).

In WA, their nesting range is relatively small and extends from the Muiron Islands to the Dampier Archipelago, a distance of approximately 400 km. The most significant breeding areas, that support hundreds of nesting females annually, are around sandy beaches within the Dampier Archipelago, Montebello Islands, Lowendal Islands and Barrow Island (Pendoley 2005, Limpus, 2009a).

The largest known nesting area for the NWS population is the sandy shoreline of Rosemary Island, within the Dampier Archipelago, particularly on the north-western side of the Island. It is believed that the Rosemary Island rookery may support up to 1,000 nesting females annually (Limpus 2009a). Low density nesting is also known from Barrow Island, Airlie Island, Muiron Islands and North West Cape/ Ningaloo coast (Cape Range) (Limpus 2009a). Nesting hawksbills have also been found on NE Regnard Island and SW Regnard Island, confirming the Regnard Islands as hawksbill rookeries (Pendoley Environmental 2009).

The hawksbill turtle nesting population within the Exmouth region is also considered important as the populations in Western Australia represent the largest remaining population in the Indian Ocean (CALM 2005). The best estimate of numbers within the Ningaloo Marine Park and Muiron Islands Marine Management Area is between 20–700 individuals (Waayers 2010).

A snapshot survey of Varanus Island and the Lowendal Islands conducted for Santos WA during October 2012 found the five most frequented beaches by hawksbills, based on the track counts, were Beacon Island (*n*=43), Parakeelya (*n*=41), Kaia (*n*=40), Rose (*n*=30) and Pipeline (*n*=28). Results of the October 2012 three-day track census program showed that Beacon Island also hosted the highest daily number of overnight emergences by hawksbills and is therefore an important nesting beach for hawksbill turtles (Pendoley Environmental 2013).

On Varanus Island, hawksbills tend to nest in greater numbers on the eastern beaches (Pipeline Beach, Harriet Beach, and Andersons Beach) (Pendoley Environmental 2013). Between 1986 and 1999, approximately 350 individual hawksbills were tagged on Varanus Island (Apache 1999). Since 2005/2006 and 2012/2013 a total of 77 new turtles have been tagged, and 221 turtles recorded nesting, with the maximum of nesting turtles (42) tagged in 2008/2009 (Pendoley Environmental 2013). The turtle tagging program on Varanus Island in the 2012–2013 breeding season reported 17 hawksbills and six were newly tagged. Pipeline Beach remained the most frequented beach on Varanus Island (Pendoley Environmental 2013). Associated with monitoring efforts and results in 2016/17; the mean population estimate for hawksbill turtles stand at 289 (+/- 33), calculated from 16 seasons (Astron 2017). From 2016/17 monitoring, Pipeline Beach and Anderson Beach were still the more frequented beaches for hawksbill nesting, with hatch and emergence success reported within ranges for other hawksbill rookeries (Limpus 2009a, Robinson 1990; cited in Astron 2017). The modelled hawksbill turtle population on Varanus Island has shown an increasing trend between 2012/13 and 2016/17 (Astron 2017).

Nesting is reported to occur between October and February in WA (Commonwealth of Australia 2017). Hawksbill turtles have been observed breeding on the NWS between July and March with peak nesting activity around the Lowendal Islands between October and December (Limpus 2009a).

Female hawksbills skip annual breeding opportunities (Kendall & Bjorkland 2001), presumably due to high energy demands of breeding (Chaloupka & Prince 2012).

Individuals may migrate up to 2,400 km between their nesting and foraging grounds (DSWEPaC 2012a). Satellite tracking of nesting turtles on Varanus Island (32 km) and Rosemary Island has shown adult turtles to feed between 50 and 450 km from their nesting beaches (DSWEPaC 2012a).

Adults tend to forage in tropical tidal and sub-tidal coral and rocky reef habitat where they feed on an omnivorous diet of sponges, algae, jelly fish and cephalopods (DSWEPaC 2012a). Hawksbill turtles are unlikely to spend significant time within off shore waters as it is too deep to act as a feeding ground. However, it is likely they may migrate through those areas.

Figure 6-3 illustrates the BIAs and critical habitats for hawksbill turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017)). The EMBA overlaps with interesting, mating, nesting, foraging and nesting BIA and nesting critical habitat.

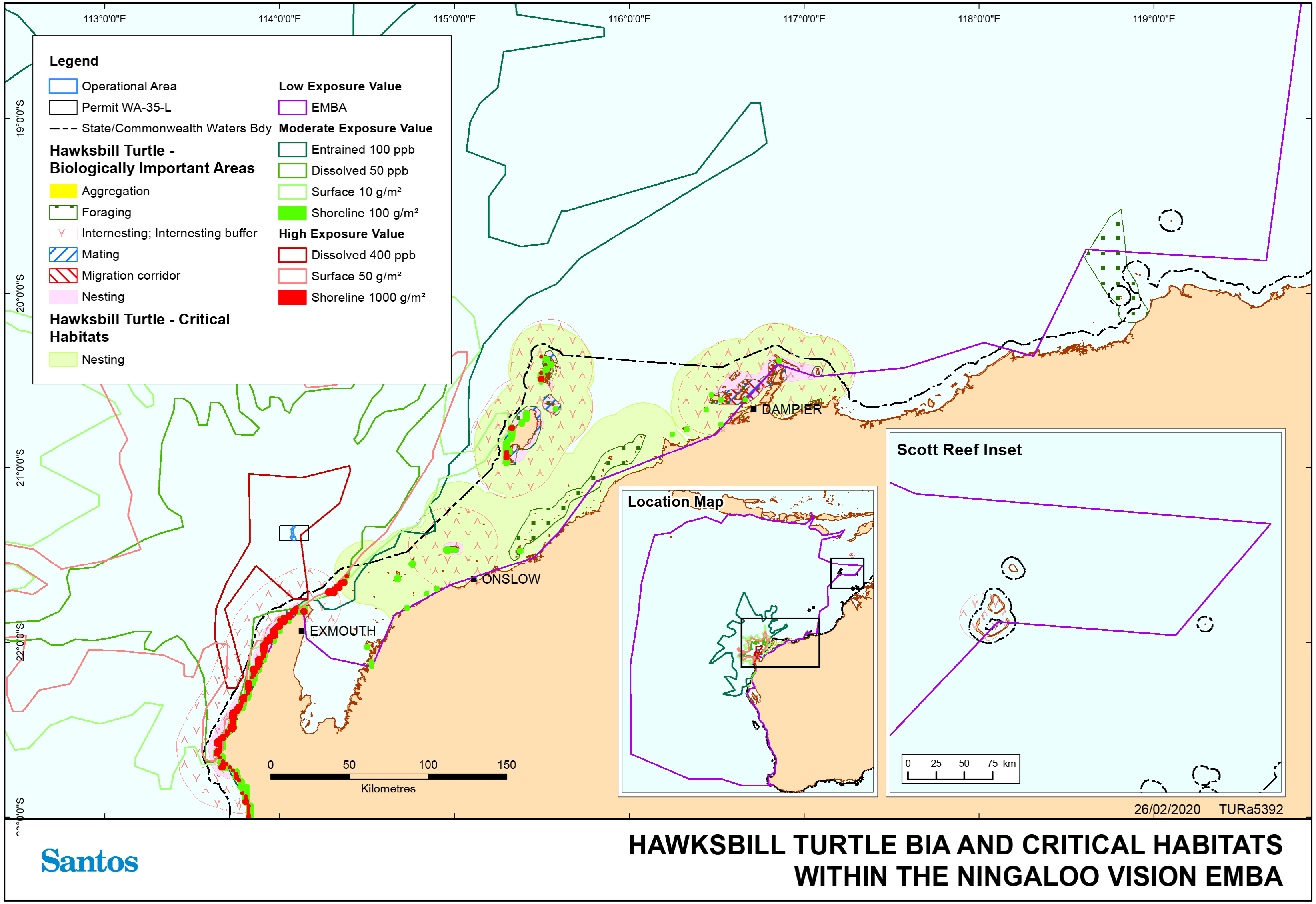

Figure 6-3: Biologically Important Areas and Critical Habitats – Hawksbill Turtle

6.1.4 Flatback Turtle

The flatback turtle (*Natator depressus*) has an Australasian distribution, with all recorded nesting beaches occurring within tropical to sub-tropical Australian waters. One third of the total breeding for the species occurs in Western Australia (WA) (Limpus 2007). The management of the flatback turtle in Australia is broken up into four breeding units, with WA supporting two of these. The southern stock nests throughout the North West shelf (NWS) and is characterised by summer nesting, and the northern stock at Cape Domett which breeds mainly in winter (Limpus 2007).

The southern WA nesting population of flatback turtles occurs from Exmouth to the Lacepede Islands off the Kimberley coast (DSEWPaC 2012d). On the NWS, significant rookeries are centred on Barrow Island especially the east coast beaches (DSEWPaC 2012b).

Montebello Islands, Thevenard Island, Varanus Island, the Lowendal Islands, King Sound and Dampier Archipelago are also significant rookeries (Pendoley 2005, Limpus 2007, Pendoley Environmental 2011). Nesting is also widespread along the mainland beaches from Mundabullangana on the Pilbara coast north, including Cemetery Beach near Port Hedland, Eighty Mile Beach and to Broome (Limpus 2007, DSEWPaC 2012b).

There have been occasional records of nesting by flatback turtles on the Jurabi Coast and Muiron Islands (CALM 2005). During turtle surveys for Santos WA flatback turtle nesting was recorded on Bessieres Islands (Astron 2014), Serrurier, Flat, Table and Round Island in previous surveys (Pendoley Environmental 2009). Flatback turtle tracks have been seen on Forty Mile beach and evidence of flatback nesting was recorded on the same beach the next day (Pendoley Environmental 2009).

Previously the status of the flatback population(s) was undetermined and although not well quantified, it was estimated to be many thousands of females (Limpus 2007). However, Pendoley *et al*. (2014) reported both Barrow Island and Mundabullangana flatback turtles as substantial reproductive populations with 4,000 and 3,500 turtles tagged at each location between 2006/2006 and 2010/2011. Cemetery beach at Port Headland had approximately 350 turtles were tagged over two seasons of monitoring (2009/2010 and 2011/12).

Satellite tracking of adult (female) flatback turtles shows they use a variety of inshore and offshore marine areas off the east and west coasts of Barrow Island. Females inter-nest close to their nesting beaches, typically in 0–10 m of water (Chevron 2008). However, flatback turtles also travel approximately 70 km and inter-nest in shallow nearshore water off the adjacent mainland coast, before returning to Barrow Island to lay another clutch of eggs. The average inter-nesting period is 13–16 days.

From long-term tagging studies on Varanus Island and Pendoley's observations, it would appear that the nesting season for flatback turtles peaks in December and January with subsequent peak hatchling emergence in February and March. Flatbacks have been observed to nest on Varanus Island between November and February (Chevron 2008, Pendoley Environmental 2011 & 2013). Population monitoring of flatback turtles on Varanus Island, calculated from 16 seasons, indicates a mean population estimate of 226 (+/- 97). Modelled Flatback turtle populations have shown a slight decline from 2008/09 to 2016/17, which is considered to be part of fluctuations in the natural cycle (Astron 2017). Flatback turtles tend to nest on all beaches on Varanus Island (Astron 2017). Flatback hatching and emergence success is noted as higher compared to that reported for other Western Australian rookeries (Pendoley et al. 2014; cited Astron 2017).

Unlike other sea turtles, the flatback turtle lacks a wide oceanic dispersal phase and adults tend to be found in soft sediment habitats within the continental shelf of northern Australia (DSEWPaC 2012b). Little information is known on the diets of flatback turtles (DSEWPaC 2012b), however, they are believed to forage on primarily soft-bodied invertebrates (Commonwealth of Australia 2017).

Figure 6-4 illustrates the BIAs and critical habitats for flatback turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017). Flatback turtles BIAs are located 7 km from the operational area. Interesting, nesting and foraging BIAs and nesting critical habitat exists within the wider EMBA.

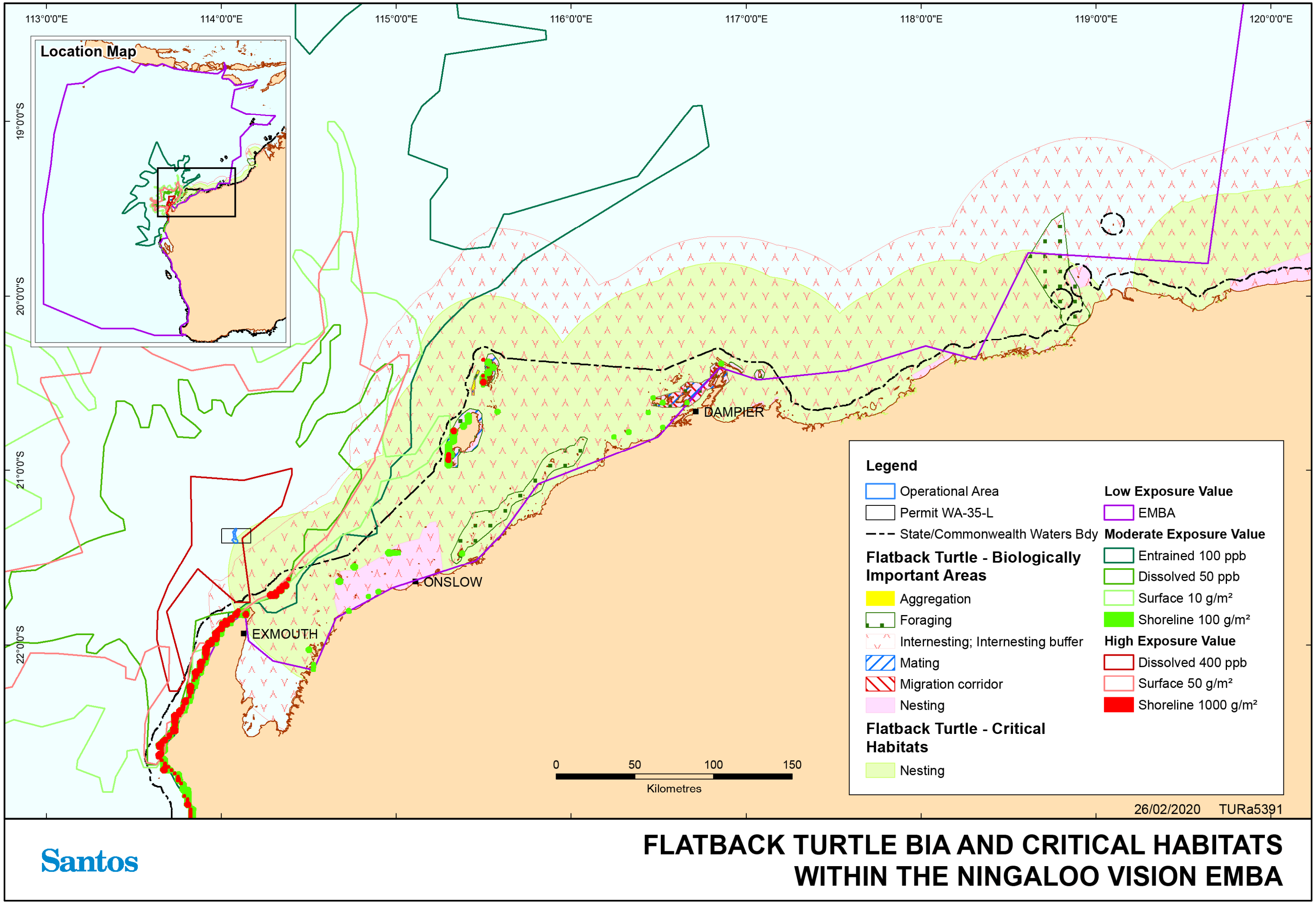

Figure 6-4: Biologically Important Areas and Critical Habitats – Flatback Turtle

6.1.5 Leatherback Turtle

The leatherback turtle *(Dermochelys coriacea*) has the widest distribution of any marine turtle, and can be found from tropical to temperate waters throughout the world (Márquez 1990). There are no major leatherback turtle centres of nesting activity that have been recorded in Australia, although scattered isolated nesting (one to three nests per annum) occurs in southern Queensland and the Northern Territory (Limpus and McLachlin 1994).

There have been several records of leatherback turtles off of the coast of WA, but no confirmed nesting sites (Limpus 2009b). Turtle observations have mainly occurred south of the NWS area and in open waters (>200 m deep) (Limpus 2009b). Due to the lack of nesting sites around Australian coastal waters, it is presumed that Leatherback turtles observed in Australian waters are migrating from neighbouring countries to utilise feeding grounds in Australia (Limpus 2009b).

The leatherback turtle will feed at all levels of the water column and is carnivorous feeding mainly on pelagic, soft-bodied marine organisms such as jellyfish, which occur in greatest concentrations in areas of upwelling or convergence (DSEWPaC 2012d). The leatherback turtle is a highly pelagic species with adults only going ashore to breed.

No leatherback turtle BIAs or critical habitats are found within the EMBA.

6.1.6 Olive Ridley Turtles

Olive Ridley turtles (Lepidochelys olivacea) are the least common turtle species encountered with critical nesting habitats occurring near Vulcan Island, Darcy Island, Prior Point and Llanggi and Cape Leveque (Commonwealth of Australia 2017). This species forages within the shallow benthic habitats of northern Western Australia and is thought to feed primarily on gastropods and small crabs within the benthic, soft-bottomed communities of the continental shelf (Limpus 2009). Olive Ridley turtles forage as far south as the Dampier Archipelago-Montebello Islands.

BIAs for this endangered species are known to occur in the vicinity of Joseph Bonaparte Depression (DSEWPaC 2012b, Environment Australia 2003).

No Olive Ridley turtle BIAs are found within the EMBA. Critical habitat is present a Cape Leveque, Prior Point and Llanggi Darcy Island and Vulcan Island, within the EMBA.

6.2 Sea snakes

Storr *et al*. (1986) estimate nine genera and 22 species of sea snakes occur in WA waters, with 25 listed marine seasnake species being recorded in the PMST search areas **(Appendix D-2 and D-3)**. Little is known of the distribution of individual species, population sizes or aspects of their ecology. Sea snakes are essentially tropical in distribution, and habitats reflect influences of factors such as water depth, nature of seabed, turbidity and season (Heatwole and Cogger 1993). Sea snakes and kraits are widespread throughout waters of the NWS in offshore and nearshore habitats. They can be highly mobile and cover large distances or they may be restricted to relatively shallow waters and some species must return to land to eat and rest. In the north-west region of Western Australia, no BIAs have been designated for sea snakes. However, both Ashmore Reef and Cartier Island are characterized for both a high density and high diversity of sea snakes (DSEWPaC 2012b).

The short-nosed seasnake (Aipysurus apraefrontalis)of seasnake listed as threatened under the EPBC Act identified in the Protected Matters search for the EMBA.

6.2.1 Short-nosed Seasnake

The short-nosed seasnake (*Aipysurus apraefrontalis*) is listed as critically endangered under the EPBC Act and the *Biodiversity Conservation Act 2016.* It is a fully aquatic, small snake and is endemic to WA. It has been recorded from Exmouth Gulf, WA to the reefs of the Sahul Shelf, in the eastern Indian Ocean. This species is believed to show strong site fidelity to shallow coral reef habitats in less than 10 m of water, with most specimens having been collected from Ashmore and Hibernia reefs (Minton & Heatwole 1975, Guinea and Whiting 2005).

The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (McCosker 1975, Cogger 2000). The species has been observed during daylight hours, resting beneath small coral overhangs or coral heads in 1–2 m of water (McCosker 1975). Guinea and Whiting (2005) reported that very few short-nosed seasnakes moved even as far as 50 m away from the reef flat and are therefore unlikely to be expected in high numbers in off shore, deeper waters.

6.3 Biologically Important Areas/Critical Habitats – Marine Reptiles

Table 6-3 provides an overview of BIAs in the EMBA for reptiles, as identified by the DoAWE and critical habitats identified in associated recovery plans. No BIAs or critical habitats are within the operational area or PW mixing zone. The DoAWE may make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that ‘habitat critical to the survival of the listed threatened species’ is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[4].

In addition, both the EPBC Act and WA Biodiversity Conservation Act 2016 and associated regulations (2018) provide for the listing of critical habitat - habitat ‘critical to the survival of the threatened species’. To date no critical habitat in WA has been listed under either Act.

[4] Further background information on BIA and identification of critical habitat in recovery plans is provided in Section 5.3.10

Table 6-3: Biologically important areas/critical habitats and geographic locations - reptiles

Species	Scientific name	Aggregation area and use	Biologically important areas within EMBA	Critical habitats within EMBA
Loggerhead turtle	*Caretta caretta*	Nesting, migration, foraging and internesting – Islands and coastline of the Kimberley region and islands of the North West Shelf	Cohen Island De Grey River Dirk Hartog Island Gnarloo Bay Lowendal Island Montebello Island Murion Island Ningaloo Coast and Jurabi coast Rosemary Island	Exmouth and Ningaloo coast Gnaraloo Bay and beaches Shark bay, all coastal and island beaches out the to the northern tip of Dirk Hartog Island
Green turtle	*Chelonia mydas*	Nesting, migration foraging and internesting – Offshore islands in the Browse Basin, North West Shelf and Kimberley/Pilbara coastlines Mating/nesting – Dampier Archipelago Basking – Middle Island	Barrow Island Browse Island Coral reef habitat west of the Montebello group. Extends the entire length of Montebellos Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Island Delambre Island Dixon Island Greens - inshore tidal and shallow subtidal areas around Barrow Island Hawksbills - shallow water coral reef and artificial reef (pipeline) habitat Legendre Island, Huay Island Middle Is. West Coast Barrow Island West Coast and North Coast Montebello Island - Hermite Island, NW Island, Trimouille Island Montebello Islands North and South Muiron Island North Turtle Island North West Cape Scott Reef Scott Reef - Sandy Islet Seringapatam Reef String of islands between Cape Preston and Onslow, inshore of Barrow Is	Mainland east of Mary island to mainland adjacent to Murrara Island including all offshore islands Browse Island Adele Island Lacepede Island Dampier Archipelago Barrrow Island Montebello Islands Serrier Island and Thevenard Island Exmouth Gulf and Ningaloo Coast
Hawksbill turtle	*Eretmochelys imbricata*	Nesting, migration, foraging and internesting – Offshore	Ah Chong and South East Is	Cape Preston to mouth of Exmouth Gulf (including

Species	Scientific name	Aggregation area and use	Biologically important areas within EMBA	Critical habitats within EMBA
		islands in the Browse Basin, North West Shelf and Kimberley/Pilbara coastlines Mating/nesting/internesting – Lowendal group, Montebello Islands	Barrow Island Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Is Delambre Island Delambre Island (and other Dampier Archipelago Islands) Greens - inshore tidal and shallow subtidal areas around Barrow Island Hawksbills - shallow water coral reef and artificial reef (pipeline) habitat Lowendal Island Group Montebello Island - Hermite Island, NW Island, Trimouille Island Montebello Island, Trimoulle and NW islands Ningaloo coast and Jurabi coast Rosemary Island Scott Reef String of islands between Cape Preston and Onslow, inshore of Barrow Island Thevenard Island Varanus Island	Montebello Islands and Lowendal Islands) Dampier Archipelago (including Delambre Island and Rosemary Island)
Flatback turtle	*Natator depressus*	Nesting, migration, foraging, internesting – Islands of the North West Shelf and the Pilbara/Kimberley coastlines Mating, nesting – Barrow Island	Eighty Mile beach Barrow Island Cape Thouin/ Mundabullangana/Cowrie Beach Coral reef habitat west of the Montebello group. Extends the entire length of Montebellos Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Is Delambre Island Dixon Island Holothuria Zone (Northern Kimberley, Holothuria Banks) Intercourse Island Legendre Island, Huay Is	Cape Domett and Lacrosse Island Eighty Mile beach Cemetary beach Eco Beach Mundabullangana Beach Dampier Archipelago Barrow Island, Montebello Island, coastal islands from Cape Preston to Locker Island

Species	Scientific name	Aggregation area and use	Biologically important areas within EMBA	Critical habitats within EMBA
			Montebello Island - Hermite Island, NW Island, Trimouille Island North Turtle Island Port Hedland, Cemetery Beach Port Hedland, Paradise Beach Port Hedland, Pretty Pool String of islands between Cape Preston and Onslow, inshore of Barrow Is Thevernard Island - South coast West of Cape Lambert	

7. Marine Mammals

Forty species of listed marine mammals are known to occur in the EMBA. Five of these occur within the operational area according to the Protected Matters search. An examination of the species profile and threats database (DoEE 2017a) showed that some listed mammal species are not expected to occur in significant numbers in the marine and coastal environments in the EMBA due to their terrestrial distributions. Hence, these species are not discussed further.

Of the remaining listed species, six are listed as threatened and thirteen migratory, (BIAs for marine mammals are discussed in **Table 7-2**). Refer to **Table 3-6** of the Ningaloo Vision Operations EP for the list of marine mammals found within the EMBA.

In addition, the New Zealand fur-seal *(Arctocephalus forsteri)*, has been identified as a species of relevance to the EMBA. The New-Zealand fur seal is listed as a protected species under WA Biodiversity Act 2016, but not listed as threatened under the EPBC Act.

7.1 Threatened & Migratory Species

7.1.1 Sei Whale

Sei whales have a worldwide, oceanic distribution, ranging from polar to tropical waters. Sei whales tend to be found further offshore than other species of large whales (Bannister *et al*. 1996).

Sei whales move between Australian waters and Antarctic feeding areas however they are only infrequently recorded in Australian waters (Bannister *et al*. 1996) and their movements and distribution in Australian waters is not well known (DoEE 2017a). There are no known mating or calving areas in Australian waters (Parker 1978 in DoEE 2017a). The National Conservation Values Atlas currently record no BIAs for this species (DoEE 2017b). Surveys of the Bonney Upwelling (outside of the EMBA) between 2000 and 2003 recorded sightings of sei whales feeding during summer and autumn, indicating that this is potentially an important feeding ground (DoEE 2017b).

7.1.2 Blue Whale

Two subspecies of blue whale are recorded in Australian waters; the southern (or true) blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). Southern blue whales are believed to occur in waters south of 60°S and pygmy blue whales occur in waters north of 55°S (i.e. not in the Antarctic) (DEWHA 2008). By this definition all blue whales in waters from Busselton to the Northern Territory border are assumed to be pygmy blue whales, and are discussed below.

Pygmy blue whales have a southern hemisphere distribution, migrating from tropical water breeding grounds in winter to temperate and polar water feeding grounds in summer (Bannister *et al*. 1996, Double *et al*. 2014). The Western Australian migration path takes pygmy blue whales down the Western Australian coast to coastal upwelling areas along southern Australia (Gill 2002) and south at least as far as the Antarctic convergence zone (Gedamke *et al*. 2007).

Tagging surveys have shown pygmy blue whales migrating northward relatively near to the Australian coastline (100 km) until reaching North West Cape after which they travelled offshore (240 km) to Indonesia. Passive acoustic data documented pygmy blue whales migrating along the Western Australian shelf break (Woodside 2012).

The northern migration passes the Perth Canyon from January to May and north bound animals have been detected off Exmouth and the Montebello Islands between April and August (Double *et al*. 2012, McCauley & Jenner 2010). During the southern migration, pygmy blue whales pass south of the Montebello Islands and Exmouth from October to the end of January, peaking in late November to early December (Double *et al*. 2012).

Recognised feeding areas of significance to this species, located within the EMBA include Ningaloo Reef and Perth Canyon (DEH 2005a). The Ningaloo Reef area has the capacity to offer feeding opportunities to pygmy blue whales through unique biophysical conditions able to support large biomasses of marine species (Double *et al*. 2014). Surface lunge feeding of pygmy blue whales has been observed at North West Cape and Ningaloo Reef in June (C. Jenner & M-N Jenner, unpublished data, 2001 in Double *et al*. 2014).

Breeding areas have not yet been identified, however, it is likely that pygmy blue whales calve in tropical areas of high localised production such as deep offshore waters of the Banda and Molucca Seas in Indonesia (Double *et al*. 2014, DoEE 2019b). There are no known breeding areas of significance to blue whales in waters from Busselton to the Northern Territory border.

The BIAs for blue whale and pygmy blue whale are detailed in **Table 7-2** and depicted in **Figure 7-1** and **Figure 7-2.** Blue Whale BIAs are 1,042km south of operational area and exist within the EMBA.

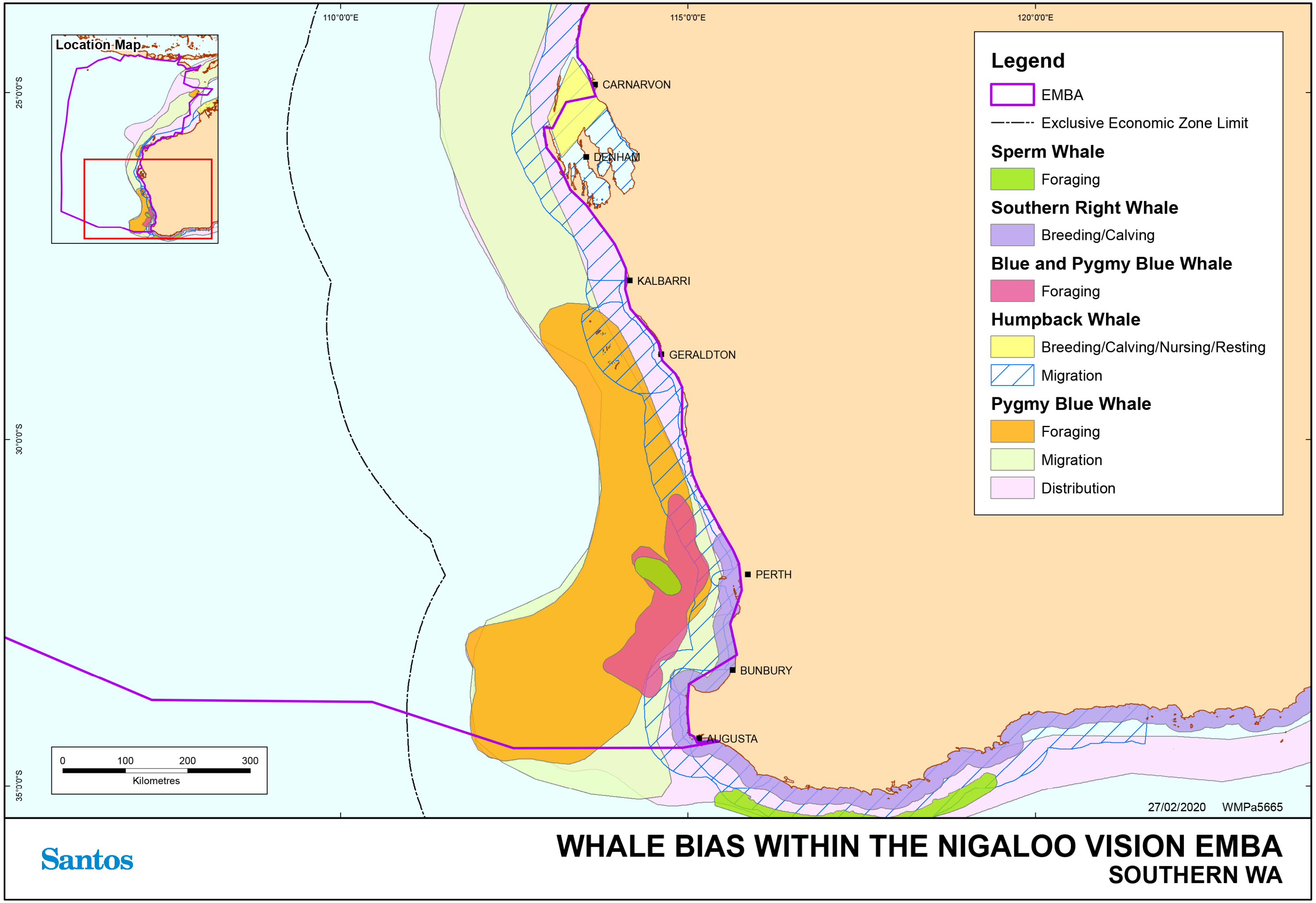

Figure 7-1: Biologically important areas – whales – Southern WA

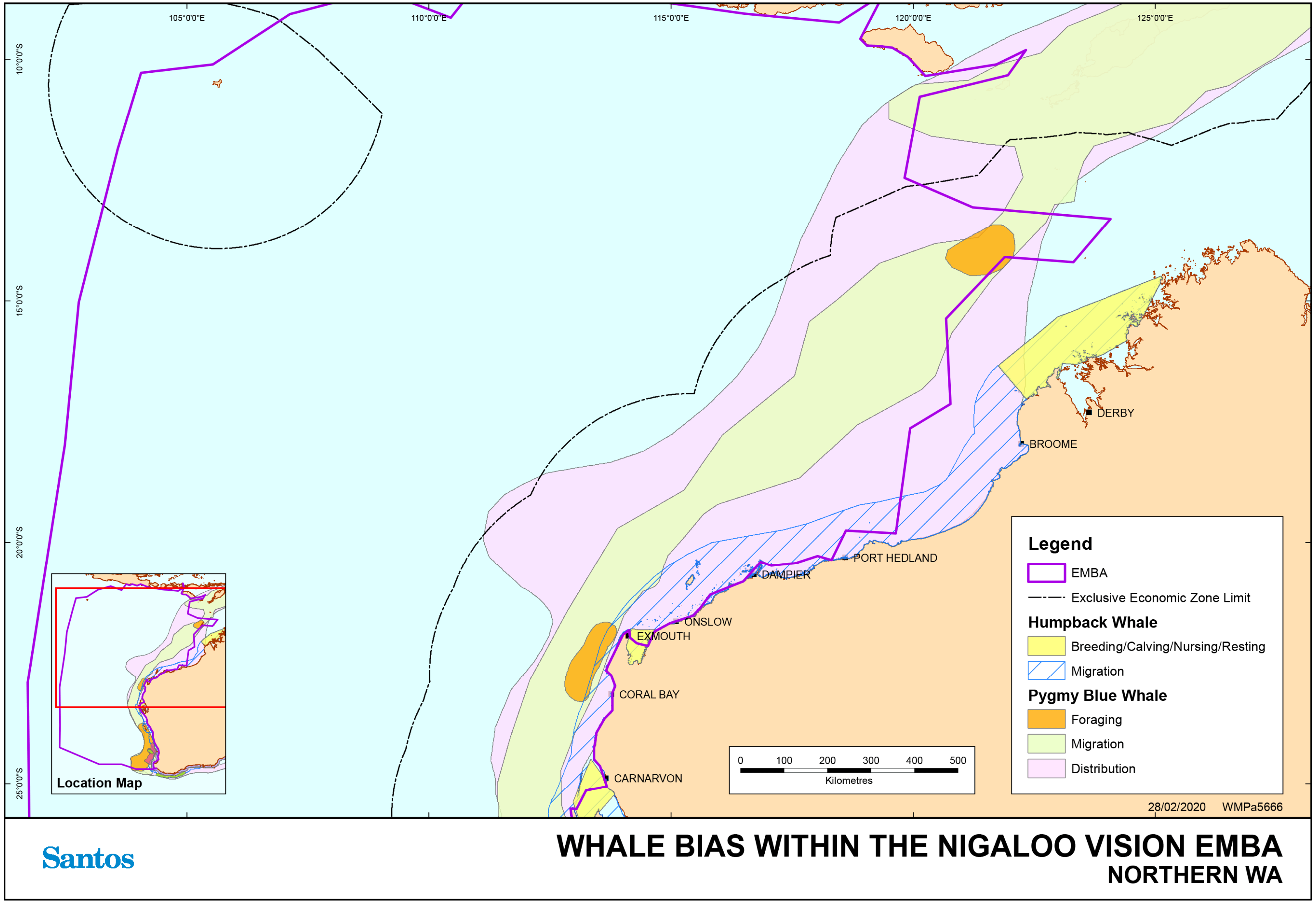

Figure 7-2: Biologically important areas – whales – Northern WA

7.1.3 Fin Whale

Fin whales have a worldwide distribution generally in deeper waters, with oceanic migrations between warm water breeding grounds and cold water feeding grounds.

The fin whale distribution in Australia is not clear due to the sparsity of sightings. Information is known primarily from stranding events and whaling records. According to the Species Profile and Threats database (DoEE 2019a); fin whales are thought to be present from Exmouth, along the southern coastline, to southern Queensland.

Migration paths are uncertain but are not thought to follow Australian coastlines (Bannister *et al*. 1996). There is insufficient data to prescribe migration times for fin whales. During summer and autumn this species has been recorded acoustically at the Rottnest Trench.

There are no known mating or calving areas in Australian waters (DoEE 2019a) and no BIAs for the fin whale are currently identified by the National Conservation Values Atlas (DoEE 2019b).

7.1.4 Southern Right Whale

The southern right whale is present in the southern hemisphere between approximately 30° and 60°S. The species feeds in the Southern Ocean in summer, moving close to shore in winter.

In Australian waters, southern right whales range from Perth, along the southern coastline, to Sydney. Sightings have been recorded as far north as Exmouth although these are rare (Bannister *et al*. 1996).

BIAs including calving and aggregation areas are recorded for this species along the southern coastline of Australia (DoEE 2019b). Details on the BIA for southern right whale are provided in **Table 7-2** and depicted in **Figure 7-1**.

The Southern Right Whale BIA for seasonal calving is 1,109 km south of the operational area. It is inside the wider EMBA.

7.1.5 Humpback Whale

Humpback whales have a worldwide distribution, migrating along coastal waters from polar feeding grounds to subtropical breeding grounds. Geographic populations are distinct and at least six southern hemisphere populations are thought to exist based on Antarctic feeding distribution and the location of breeding grounds on either side of each continent (Bannister *et al*. 1996). The population of humpback whales migrating along the Western Australian coastline was recently estimated to be greater than 33,000 whales and likely increasing at exceptionally high growth rates between 10–12% (Hedley *et al*. 2011, Salgado Kent *et al*. 2012).

The west coast Australian humpback whale population migrates from Southern Polar Ocean 'summer' feeding grounds to their northern tropical 'winter' calving/ breeding grounds in coastal waters of the Kimberley. The northern migration tends to follow deeper waters of the continental shelf, whilst the southward migration concentrates whales closer to the mainland (Jenner *et al*. 2001). Recent satellite tagging of southbound humpback whales indicate that whales generally migrated close to the coastline, within a few tens of kilometres of shore and in a corridor frequently less than 100 km (Double *et al*. 2010). Aerial surveys and noise logger recordings undertaken for Chevron's Wheatstone Project indicated that the main distribution of humpback whales were sighted at an average distance of 50 km from the mainland during the northern migration and 35 km during the southbound migration (RPS 2010a).

The precise timing of the migration varies between years by up to six weeks, influenced by water temperature, sea ice distribution, predation risk, prey abundance and the location of feeding grounds (DEWR 2007).

Peak northward migration across the North West Shelf is identified as from late July to early August, and peak southward migration from late August to early September (DotE 2015c). Data collected between 1995 and 1997 by the Centre for Whale Research indicates that the period for peak northern migration into the calving grounds in the Kimberley is mid to late July. The peak for southern migration is in the first half of September (Jenner *et al* 2001). Actual timing of annual migration may vary by as much as three (3) weeks from year to year due to food availability in the Antarctic (DMP, 2003).

Details on the BIA for humpback whales are provided in **Table 7-2** and depicted in **Figure 7-1** and **Figure 7-2**. The operational area and EMBA overlaps with BIA for migration.

7.1.6 Sperm Whale

Sperm whales typically occur in WA along the southern coastline between Cape Leeuwin and Esperance (Bannister *et al.* 1996). Sperm whales are distributed worldwide in deep waters (greater than 200 m) off continental shelves and sometimes near shelf edges, averaging 20 to 30 nautical miles offshore (Bannister *et al.* 1996). The sperm whale is known to migrate northwards in winter and southwards in summer, however, detailed information on the distribution of sperm whales is not available for the timing of migrations. Sperm whales have been recorded in deep water off the North West Cape on the west coast of Western Australia (RPS 2010b), and appear to occasionally venture into shallower waters in other areas (RPS 2010b). Details on the BIA for sperm whales are provided in **Table 7-2** and are shown in **Figure 7-1.**

Sperm Whale BIA for foraging is 1,139 km south of the operational area. It overlaps the EMBA.

7.1.7 Antarctic Minke Whale

The Antarctic minke whale is distributed throughout the Southern Hemisphere from 55°S to the Antarctic ice edge during the austral summer and has been recorded in all Australian States (Bannister et al. 1996; Perrin & Brownell 2002). Detailed information on timing and location of migrations and breading grounds on the west coast of Australia is largely unknown. However, it is believed that the Antarctic minke whale migrates up the WA coast to approximately 20°S during Australian winter to feed and possibly breed (Bannister *et al.* 1996).

7.1.8 Bryde's Whale

The Bryde's whale is found all year round in tropic and temperate waters (Kato 2002). Two forms are recognised: inshore and offshore Bryde's whales. It appears that the inshore form is restricted to the 200 m depth isobar whilst the offshore form is found in deeper waters of 500-1,000 m (DoEE 2019c). Both forms are expected to be found in 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, the location of exact breeding and calving grounds and large-scale migration patterns (DoEE 2019c). It is however, suggested that the offshore form migrates seasonally, heading towards warmer tropical waters during the winter.

7.1.9 Pygmy Right Whale

The pygmy right whale is considered the most elusive baleen whale and as a result very little is known about the whale's distribution in Australian waters. Records of the pygmy right whale in Australian waters are distributed between 32°S and 47°S and are restricted in the west by the Leeuwin current (Kemper 2002). It is possible that the pygmy right whale will be encountered in the southern extent of the EMBA, particularly in coastal areas of upwelling (Kemper 2002).

7.1.10 Killer Whale

The killer whale has a widespread global distribution and has been recorded in waters of all Australian states/territories (Bannister *et al.* 1996). Whilst more commonly found in cold, deeper waters, killer whales have been observed along the continental slope, shelf and shallow coastal areas of WA. Killer whales are known to make seasonal movements and are most likely to follow the migratory routes of their prey.

7.1.11 Indo-Pacific Humpback Dolphin

The Indo-pacific humpback dolphin is typically found in water less than 20 m deep but has been recorded in waters up to 40 m deep. This species is generally found in association with river mouths, mangroves, tidal channels and inshore reefs (DoEE 2016a). This species of dolphin is known to have resident groups that forage, feed, breed and calve in the state waters of Roebuck Bay, Dampier

Peninsula, King Sound north, Talbot Bay, Anjo Peninsula, Vansittart Bay, Napier Broome Bay and Deception Bay (DoEE 2016a).

7.1.12 Spotted Bottlenose Dolphin (Indo-Pacific bottlenose dolphin)

The spotted bottlenose dolphin (*Tursiops aduncus*) (Arafura / Timor Sea populations) is generally considered to be a warm water subspecies of the spotted bottlenose dolphin, occurring in shallow (often <10 m deep) inshore waters (Bannister et al., 1996; Hale et al., 2000). The known distribution of the spotted bottlenose dolphin extends from Shark Bay north to the western edge of the Gulf of Carpentaria in Australia (DoEE 2016b).

7.1.13 Irrawaddy Dolphin (Australian Snubfin Dolphin)

The Irrawaddy dolphin, also known as the snubfin dolphin (*Orcaella heinsohni*) is known to occur within the waters off northern Australia, extending north from Broome in Western Australia to the Brisbane River in Queensland (DoEE 2016c). Surveys have indicated that the species is typically found in protected shallow nearshore waters, generally less than 20 m deep, adjacent to river and creek mouths close to seagrass beds (DoEE 2016c). The snubfin dolphin was not recorded during any of the aerial surveys undertaken along the Dampier Peninsula coastline in the vicinity of James Price Point but were observed in Roebuck Bay from vessels on several occasions (RPS, 2010b). Based on the extensive survey effort and amenable conditions within the James Price Point coastal area during the survey, it is concluded that this species is seldom found outside of shallow and sheltered bays and inlets (DSD 2010).

7.1.14 Dusky Dolphin

The dusky dolphin's distribution is strongly linked to colder waters. In Australia, the dusky dolphin has been sighted in southern Australia from WA to Tasmania. It is presumed to be primarily an inshore species but has been known to move further offshore, possibly due to its desire for colder waters (Gill *et al.* 2000). Dusky dolphins are expected to be limited in their distribution along the WA coastline due to the presence of the southward-flowing warm water of the Leeuwin Current.

7.1.15 Australian Sea Lion

The Australian sea lion is endemic to Australia. Breeding colonies are found only in South Australian and Western Australian waters. There are currently 76 known Australian sea lion pupping locations along the coast and offshore islands between the Houtman Abrolhos Islands in Western Australia to the Pages Islands in South Australia (DSEWPaC 2013c). The species has also been recorded at Shark Bay (DoE 2014a).

BIAs for foraging, haul-out and breeding sites identified by the National Conservation Values Atlas are located south of the waters from Busselton to the NT border (DoEE 2019b). Male Australian sea lions have been recorded foraging in areas up to 60 km away from their birth colonies, with potentially larger dispersal ranges up to 180 km (Hamer *et al*. 2001). However, female Australian sea lions have restricted home ranges, with high rates of natal site fidelity and limited gene flow with other regions (Campbell 2005).

The Australian sea lion BIA in the EMBA is outlined in **Table 7-2** and is depicted in **Figure 7-3.** The EMBA overlaps with BIA for foraging**.**

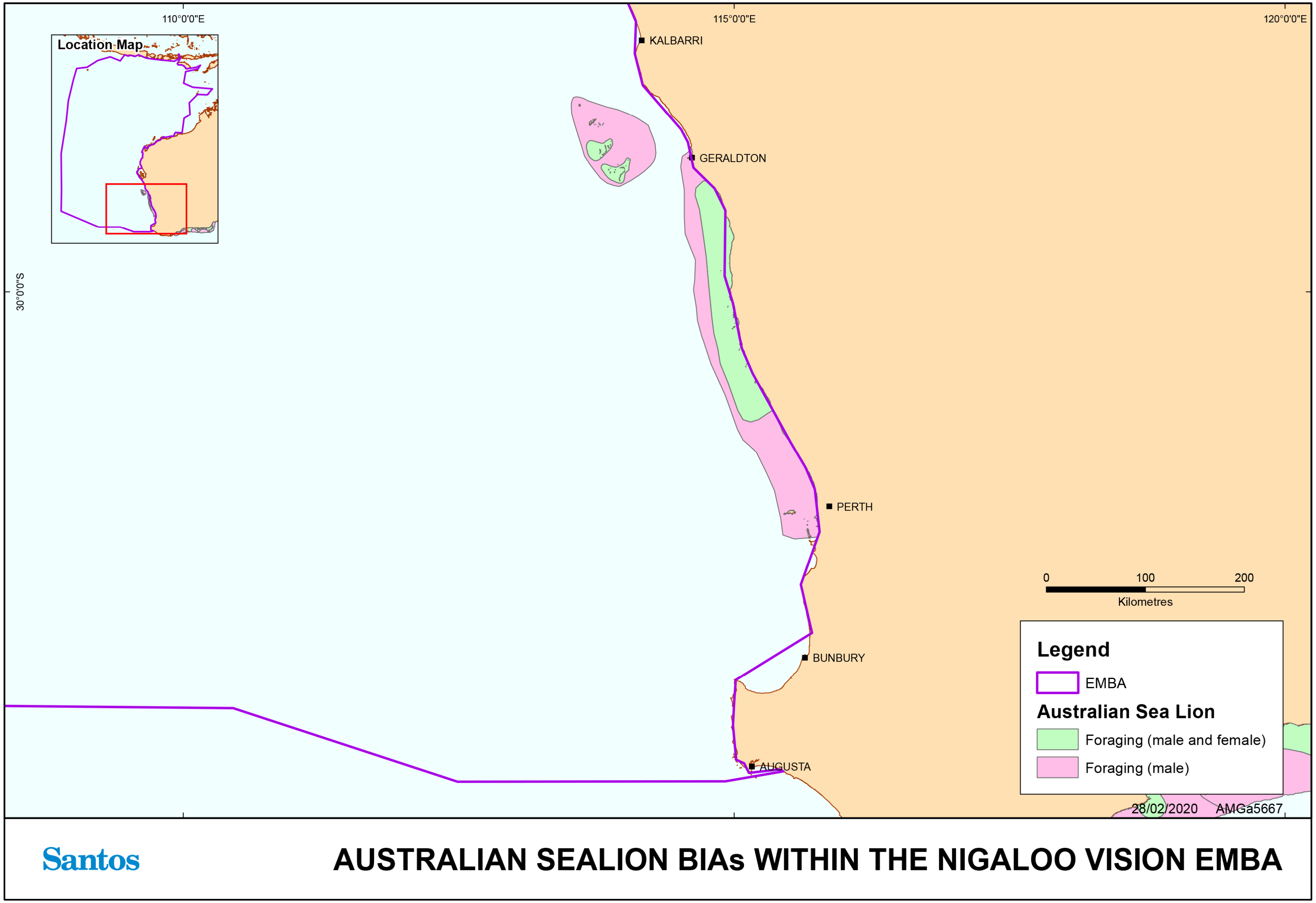

Figure 7-3: Biologically important areas – Australian sea lion

7.1.16 Dugongs

Dugongs (*Dugong dugon*) are large herbivorous marine mammals (up to 3 metres) that feed off seagrass and generally inhabit coastal areas. Key populations along the WA coast are principally located at: Shark Bay (the largest resident population in Australia), Ningaloo Marine Park and Exmouth Gulf, the Pilbara coast and offshore areas including Montebello/Barrow/Lowendal Islands, and further north at Eighty Mile Beach and off the Kimberley Coast, particularly Roebuck Bay and Dampier Peninsula (Marsh *et al*. 2002; DSEWPaC 2012). Populations are also present at Ashmore Reef. Dugong distribution and movement is based on the abundance, size and species of seagrass meadow. Dugongs can migrate hundreds of kilometres between seagrass habitat.

The dugong BIAs in the EMBA are detailed in **Table 7-2** and shown in **Figure 7-4**. The EMBA overlaps with BIA for breeding, foraging (high density seagrass beds), nursing and calving

7.1.17 New Zealand fur-seal

The New Zealand fur-seal (also known as the long-nosed fur seal) (*Arctocephalus forsteri*) is a specially protected species (Other Specially Protected) under the *Biodiversity Conservation Act 2016*.

The New Zealand fur seal is found in Ngari Capes Marine Park (two colonies) (and along other parts of Australia's southern coast).[5]

[5] Identified as a relevant species through review of *Biodiversity Conservation Act 2016* listed species for marine species without an EBPC Act listing.

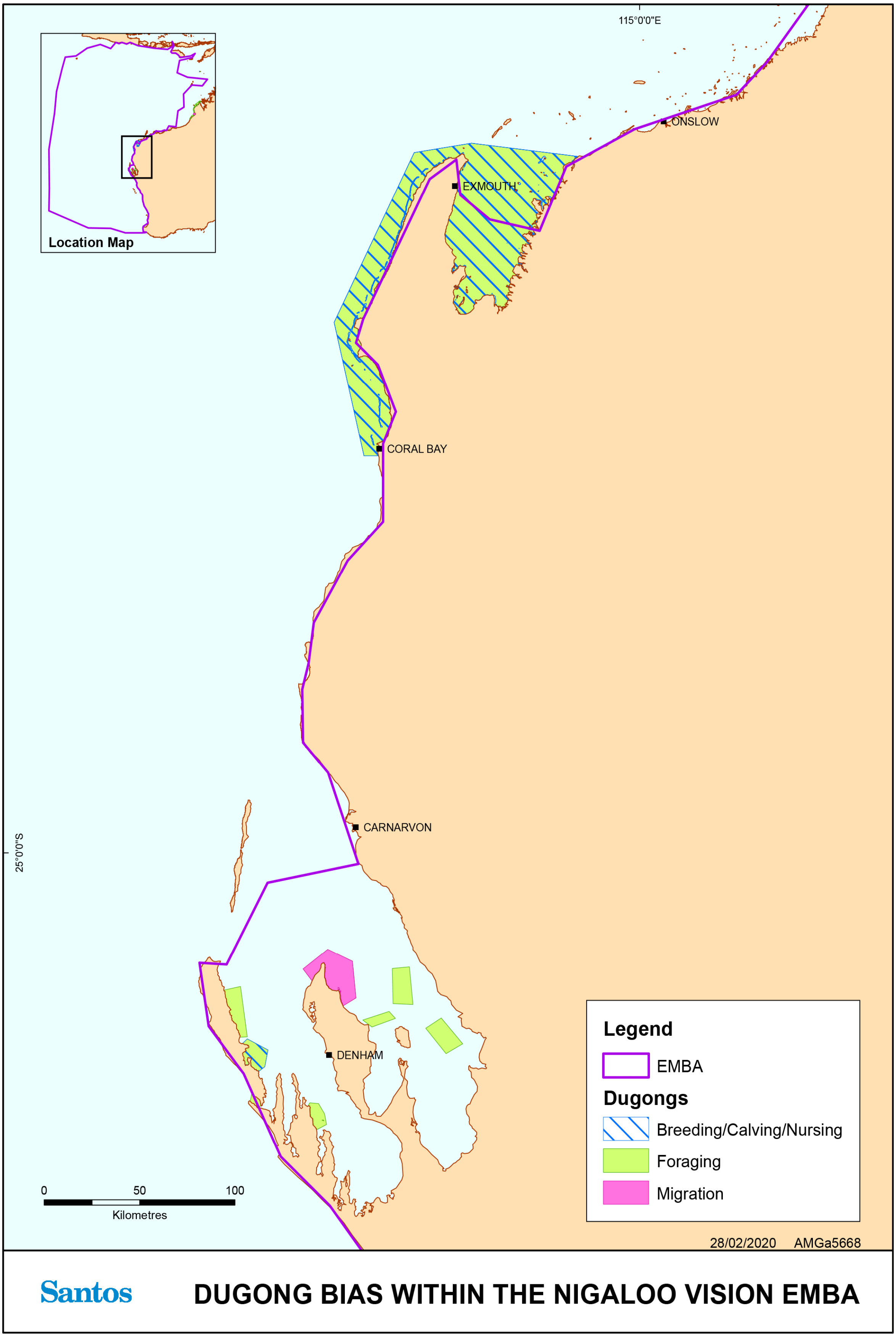

Figure 7-4: Biologically important areas – dugongs

Table 7-1: Summary of information for marine mammals listed as threatened under the EPBC Act

Aspect	Sei whale	Blue and pygmy blue whales	Fin whale	Southern right whale	Humpback whale	Australian sea lion
Species expected in area	Unknown	Yes	Unknown	Unlikely, southern distribution	Yes	Unlikely, southern distribution
Migration depth (m)	Unknown, prefers offshore waters	500-1,000	Unknown	n/a	Up to 100	n/a
Migration seasonality	Unknown	Apr to Aug (north), Oct to Jan (south)	Unknown	n/a	Jun to Nov	n/a

7.2 Biologically Important Areas / Critical Habitat – Marine Mammals

Table 7-2 below provides an overview of BIAs in the EMBA for marine mammals

The DoAWE may also make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[6].

In addition, both the EPBC Act and WA *Biodiversity Conservation Act 2016* and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species. To date no critical habitat in WA has been listed under either Act.

Table 7-2: Biologically important areas – marine mammals

Species	Scientific name	Aggregation area and use	BIAs within EMBA
Blue and pygmy blue whales	*Balaenoptera musculus*	Migration – along the continental shelf edge off the WA coastline, extending offshore near Scott Reef and into Indonesian waters Foraging – along Ningaloo reef, around Scott Reef, around the Perth canyon	Blue and pygmy blue whale - Head of the Perth Canyon Outer continental shelf from Cape Naturaliste to south of Jurien Bay Outer Perth Canyon Head of the Perth Canyon Pygmy blue whale - Augusta to Derby. Tend to pass along the shelf edge at depths of 500 m to 1000 m; appear close to coast in the Exmouth-Montebello Islands area on southern migration. From Mandurah to south of Cape Naturaliste, seaward to the 50 m depth contour Indonesia- Banda Sea Ningaloo Perth Canyon

[6] Further background information on BIA and identification of critical habitat in recovery plans is provided in **Section 5.3.10**.

Species	Scientific name	Aggregation area and use	BIAs within EMBA
			Scott Reef
Southern right whale	*Eubalaena australis*	Breeding/calving – along the south west and southern coastline of WA/SA	Bunbury area, WA Camac Island/Fremantle, WA Coast Cape Naturaliste to Cape Leeuwin Coast Perth region to Cape Naturaliste Geographe Bay, WA Perth to Kangaroo Island
Humpback whale	*Megaptera novaeangliae*	Breeding/calving/nursing/resting –Exmouth Gulf, Shark Bay Migration - northern migration deeper waters of the continental shelf, southward migration – along the WA mainland	Cape Leeuwin to Houtman Abrolhos Cape Naturaliste Cape Naturaliste to Cape Leeuwin Exmouth Gulf Flinders Bay Geographe Bay Houtman Abrolhos Islands North of Houtman Abrolhos Shark Bay The migration corridor extends from the coast to out to approximately 100 km offshore in the Kimberley region extending south to North West Cape. From North West Cape to south of shark Bay the migration corridor is reduced to approximately 50 km. West coast - Lancelin to Kalbarri West coast- Bunbury to Lancelin including Rottnest Island
Sperm whale	*Physeter macrocephalus*	Foraging - west end of Perth Canyon and Albany Canyons	Western end of Perth canyon Albany Canyons - Immediately south of the continental shelf edge extending over the continental slope
Australian sea lion	*Neophoca cinerea*	Foraging – male and female – Houtman Abrolhos Island, mid-west coast (more restricted spatial extent than males) Foraging – males Houtman Abrolhos Island, mid-west coast down to Perth Breeding – Buller Island, North Fisherman Island, Beagle Island, Albrolhos Island Haul Out Sites – North Cervantes Island, Sandland Island, Albrolhos Island	Houtman Abrolhos Islands Mid-west coast, includes Beagle Island, Fisherman Island, Jurien Bay, Cervantes and Buller Colonies From Recherche Archipelago to Doubtful Islands – Key colonies, Kimberly island, Glenny and Wickham Island. Haul-Off rock
Dugong	*Dugong dugon*	Foraging – Shark Bay, Exmouth and Ningaloo coastline Breeding/calving/nursing – Exmouth and the Ningaloo coastline	Between Peron Peninsula and Faure Island, Shark Bay Dirk Hartog Island, Shark Bay East of Faure Island, Shark Bay Exmouth Gulf

Species	Scientific name	Aggregation area and use	BIAs within EMBA
			North East Peron Peninsula, Shark Bay North of Faure Island, Shark Bay South Passage, Shark Bay Useless Loop, Shark Bay

8. Birds

Marine waters and coastal habitat in the EMBA contain key habitats that are important to birds, including offshore islands, sandy beaches, tidal flats, mangroves and coastal and pelagic waters. These habitats support a variety of birds which utilise the area in different ways and at different times of the year (DSEWPaC 2012a). Birds can be broadly grouped according to their preferred foraging habitat as coastal/ terrestrial birds, seabirds and shorebirds.

Coastal or terrestrial species inhabit the offshore islands and coastal areas of the mainland throughout the year. These species are either primarily terrestrial, or they may forage in coastal waters. Resident coastal and terrestrial species include osprey (*Pandion haliaetus*), white-bellied sea eagle (*Haliaeetus leucogaster*), silver gull (*Larus novaehollandiae*) and eastern reef egret (*Egreta sacra*) (DEWHA 2008).

Seabirds include those species whose primary habitat and food source is derived from pelagic waters. These species spend the majority of their lives at sea, ranging over large distances to forage over the open ocean. Seabirds present in the area include terns, noddies, petrels, shearwaters, tropicbirds, frigatebirds boobies and albatrosses (DEWHA 2008).

Shorebirds, including waders, inhabit the intertidal zone and adjacent areas. Some shorebird species, including oystercatchers are resident (Surman & Nicholson 2013). Other shorebirds are migratory and include species that utilise the East Asian–Australasian Flyway, a migratory pathway for millions of migratory shorebirds that travel from Northern Hemisphere breeding grounds to Southern Hemisphere resting and foraging areas. Shorebirds that regularly migrate through the area include the *Scolopacidae* (curlews, sandpipers etc.) and *Charadriidae* (plovers and lapwings) families.

Surveys in the area by Santos WA and other agencies have built a picture of diverse avifauna. A summary of research is discussed below, followed by information on threatened and migratory birds. Wetlands of international importance are discussed in **Section 9.2**.

The following sections discuss the results of regional surveys which overlap the EMBA.

8.1 Regional Surveys

8.1.1 Abrolhos Islands

The Abrolhos Islands are one of the most significant seabird nesting areas in the eastern Indian Ocean with over two million birds breed on the islands and small rocky atolls in the Abrolhos (DoF 2012). The mixture of species is unique, as subtropical and tropical species, and littoral and oceanic foragers, share the breeding islands. A total of 95 bird species have been recorded as residents or visitors to the Abrolhos Islands. Of these 35 species are known to breed at the Abrolhos (DoF, 2012):

+ Common noddy (rookery – Pelseart Island): The Abrolhos supports 80 per cent of the Australian breeding population of the common noddy (Anous stolidus) with up to 250,000 common noddies breed at Pelsaert Island. These birds lay their eggs in spring, but the actual month can vary, depending on their food supply and the weather conditions existing in offshore waters (DoF 2012);
+ Caspian tern (rookeries – Leo Island, West Wallabi Island and Pelsaert Island): Unlike other more social terns, Caspian terns (Hydroprogne caspia) are usually solitary nesters. There are less than 150 of these breeding at the Abrolhos, across 22 islands (DoF 2012);
+ Wedge-tailed shearwaters (rookeries): The Abrolhos are the most important breeding sites in Australia for the wedge tailed shearwater (Ardenna pacifica), with between 500,000 and a million of these birds breeding there every year, predominantly on West Wallabi Island. The wedge-tailed shearwater breeding colonies at the Abrolhos are the largest in Australia (DoF 2012);
+ Bridled tern (rookeries – Gun Island, Leo Island, Pelsaert Island, Little North Island, Fisherman Islands, Beagle Islands and Penguin Island): Bridled terns (Onychoprion anaethetus) breed on 90 islands throughout the Abrolhos. These birds fly north for the winter, through Indonesia to waters around the Philippines. There are approximately 4,000 bridled terns who return to the Abrolhos around October every

year to lay their eggs. Bridled terns nest on more islands in the Abrolhos than any other bird species (DoF, 2012);

+ Osprey (nesting area – Pelseart Island): Up to 100 eastern ospreys (Pandion cristatus) nest at a number of sites throughout all three island groups at the Abrolhos, including nesting platforms made from converted rock lobster pots and stacked fishing equipment on jetties (DoF 2012);
+ White-bellied sea eagle (nesting area – West Wallabi Island): At the Abrolhos, there are up to 50 breeding white-breasted sea eagles (Haliaeetus leucogaster), spread across all three island groups (DoF 2012);
+ Australian lesser noddy (feeding area and rookeries Morley Island, Wooded Island and Pelseart Island): In Australia the Australian lesser noddy is only known to breed in this area and is known to forage between the islands and the continental shelf edge; and
+ Other areas rookeries identified for both the wedge-tailed shearwater and bridled tern within the south west area include Lancelin Island, Rottnest Island and Safety Bay.

8.1.2 North West Cape

Avifauna surveys of the North West Cape have recorded 144 bird species, one third of which are seabirds and shorebirds (resident and migratory) (May *et al*. 1983). Approximately 33 species of seabirds and shorebirds are found in the Ningaloo Marine Park with the main breeding areas at Mangrove Bay, Mangrove Point, Point Maud, the Mildura wreck site and Fraser Island (CALM & MPRA 2005a).

8.1.3 Murion Islands and Exmouth Gulf Islands

Murion Islands and Exmouth Gulf Islands are generally lacking in published bird observations data. Early indications from surveys commissioned by Santos WA in 2013/14 indicate that South and North Murion Islands are regionally significant in terms of wedge-tailed shearwater (*Puffinus pacificus*) nesting, whilst Bessiers and Fly islands are also significant (Surman pers comm. 2013). Nine coastal/terrestrial species and 21 shorebirds were identified on the Murion and Exmouth Gulf Islands during the first of these surveys and seven bird species were recorded nesting (Surman 2013).

8.1.4 Dampier Archipelago/Cape Preston Region

The Dampier Archipelago/Cape Preston region is a nesting area for at least 16 species of seabirds. Many of the islands and rocks in the area are known breeding grounds for birds, including wedge-tailed shearwaters (*Puffinus pacificus*), Caspian terns (*Sterna caspia*), bridled terns (*Sterna anaethetus*) and roseate terns (*Sterna dougallii*). Small islands and islets such as Goodwyn Island, Keast Island and Nelson Rocks provide important undisturbed nesting and refuge sites and Keast Island provides one of the few nesting sites for pelicans in WA (CALM & MPRA 2005b).

8.1.5 Barrow Island and Lowendal Island Group

Barrow Island and surrounding islands have a diverse avifauna comprising at least 110 species, including 11 resident land birds, eight resident seabirds, 17 seabirds, 22 species of migratory waders, six resident shorebirds and 43 irregular visitors (Surman 2003). The avifauna of Barrow Island is thus poor in terms of land birds and waterfowl compared to mainland areas of the Pilbara, but rich in migratory waders and seabirds. Compared to other nearby offshore islands, Barrow Island has substantially more migratory waders but fewer breeding seabirds (Surman 2003).

The Lowendal Island Group has a diverse avifauna comprising 89 recorded species (Dinara Pty Ltd. 1991, Burbidge *et al*. 2000). Six species of resident land birds and six species of raptors have been recorded at the Lowendal Islands (Surman & Nicholson 2012). Up to fourteen seabird species have been observed at any one time during annual surveys of the Lowendal Islands between 2004 and 2012. Surveys at the Montebello Islands have recorded 70 bird species. This includes 12 species of seabirds and 14 species of migratory shorebirds (Burbidge *et al*. 2000).

8.1.6 Varanus, Airlie, Serrurier, Bridled, Abutilon, Beacon and Parakeelya Islands

Wedge-tailed shearwaters have been identified to nest on Varanus, Airlie, Serrurier and Bridled Islands (Astron 2017a). Breeding participation on the islands appears to be largely influenced by pre-breeding oceanographic conditions (Astron 2017a). Monitoring in 2016/17 was undertaken by Santos WA and demonstrated the colony sizes for wedgetailed shearwaters to be within or above previously reported ranges (Astron 2017a). This is informed though monitoring that has been undertaken under the Integrated Shearwater Monitoring Program (ISMP), established in 1994.

In 2016/17, areas of potential wedge-tailed shearwater nesting habitat were recorded on Varanus Island (5.53 ha) and Airlie Island (12.47 ha) and surrounding islands of Bridled (2.94 ha), Serrurier (130.89 ha), Abutilon (2.02 ha) and Parakeelya (1.66 ha) (Astron 2017a). The number of wedge-tailed shearwater breeding pairs was also estimated for each of Varanus (1,492 +/- 702), Airlie (600 +/- 124), Bridled (1,039 +/- 342), Serrurier (23,240 +/- 4,341), Abutilon (317 +/- 210) and Parakeelya (172 +/- 138) islands (Astron 2017a).

Other seabird species utilising Abutilon, Beacon, Bridled and Parakeelya islands for nesting include bridled terns, silver gulls, crested terns and lesser crested terns. Monitoring for these seabirds in 2016/17 was also completed by Santos WA, with monitoring results concluded to support previous trends for all species. Bridled terns mainly utilise Abutilon, Bridled and Parakeelya islands for breeding, with smaller numbers noted on Beacon and Varanus Islands. The bridled terns have not been recorded on Airlie Island and only in very small numbers on Varanus Island (Astron 2017b).

Silver gull numbers appear to be growing across the region (2010/2011). However, reasons for this are unknown but considered possibly to be due to greater prey availability or immigration from the mainland (Astron 2017b). Silver gulls have been found to utilise Bridled, Parakeelya, Abutilon and Beacon islands longer term for breeding. Silver gulls have not been identified to nest on Varanus island and were only recorded nesting on Airlie island for the first time in 2016/17 since monitoring commencement in 2004/05 (Astron 2017b).

The crested tern and lesser crested tern are noted as nomadic breeders that appear to use a consistent subset of islands for breeding. In 2016/17, Beacon Island was the favourable nesting site for the crested tern and lesser crested tern (Astron 2017b). Surveys in the vicinity of Port Hedland (Bennelongia 2011) recorded 23 species of migratory shorebird between 2002 and 2011. Terrestrial/coastal and seabird species were not targeted. A total of 4,248 migratory shorebirds of 18 species were observed during the field survey in April 2011.

8.2 Threatened Species

A Protected Matters search of the EMBA identified 55 bird species listed under the EPBC Act as threatened. A PMST search of the operational area identified 6 threatened species of bird under the EPBC Act.

An examination of the species profile and threats database (DoEE 2019a) and The Action Plan for Australian Birds (Garnet 2011) showed that some listed bird species are not expected to occur in significant numbers in the marine and coastal environments in the EMBA due to their terrestrial or southern distributions. Hence, these species are not discussed further.

EPBC Act threatened species expected to occur in the EMBA are listed in **Table 8-1** along with their WA conservation status (as applicable) and discussed below.

BIAs for birds are detailed in **Table 8-5** and depicted in **Figure 8-1** and **Figure 8-2**.

Wedge-tailed shearwater is the only bird species to have a BIA overlap with the operational area.

Table 8-1: Birds listed as threatened under the EPBC Act within the EMBA

Species	Conservation Status			Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016*	Other WA Conservation Code		
Shorebirds					
Red knot (*Calidris canutus*)	Endangered	Endangered	-	Species or species habitat known to occur within area	None - No BIA defined
Curlew sandpiper (*Calidris ferruginea*)	Critically endangered	Critically endangered	-	Species or species habitat known to occur within area	None - No BIA defined
Great knot (*Calidris tenuirostris*)	Critically endangered	Critically endangered	-	Roosting known to occur within area	None - No BIA defined
Greater sand plover (*Charadrius leschenaultia*)	Vulnerable	Specially protected (migratory)	-	Roosting known to occur within area	None - No BIA defined
Lesser sand plover (*Charadrius mongolus*)	Endangered	Endangered	-	Roosting known to occur within area	None - No BIA defined
Western Alaskan bar-tailed godwit (*Limosa lapponica baueri*)	Vulnerable	Vulnerable	-	Species or species habitat known to occur within area	None - No BIA defined
Northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri*)	Critically endangered	Critically endangered	-	Species or species habitat known to occur within area	None - No BIA defined
Eastern curlew (*Numenius madagascariensis*)	Critically endangered	Critically endangered	-	Species or species habitat known to occur within area	None - No BIA defined
Australasian bittern (*Botaurus poiciloptilus*)	Endangered	Endangered	-	Species or species habitat known to occur within area	None - No BIA defined
Australian painted snipe (*Rostratula australis*)	Endangered	Endangered	-	Species or species habitat may occur within area	None - No BIA defined
Bar-tailed godwit (*Limosa lapponica bauera*)	Vulnerable	Vulnerable	-	Species or species habitat likely to occur within area	None- No BIA defined
Barrow	Vulnerable	-	-	Species or species habitat	None-No BIA defined

Species	Conservation Status			Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016*	Other WA Conservation Code		
Island Black-and-white Fairy-wren				likely to occur within area	
Dirk Hartog Black-and-white Fairy-wren	Vulnerable	Vulnerable	-	Dirk Hartog Black-and-white Fairy-wren	None-No BIA defined
Seabirds					
Australian lesser noddy (*Anous tenuirostris melanops)*	Vulnerable	Endangered	-	Breeding known to occur within area	Yes – refer to **Table 8-5**
Fairy prion (southern) (*Pachyptila tutur subantarctica)*	Vulnerable	-	-	Species or species habitat known to occur within area	None - No BIA defined
Southern royal albatross (*Diomedea epomophora)*	Vulnerable	Specially protected (migratory)	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Northern royal albatross (*Diomedea sanfordi)*	Endangered	Endangered	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Amsterdam albatross (*Diomedea amsterdamensis*)	Endangered	Critically endangered	-	Species or species habitat may occur within area	None - No BIA defined
Antipodean albatross (*Diomedea antipodensis)*	Vulnerable	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Sooty Albatross (*Phoebetria fusca)*	Vulnerable	Endangered	-	Species or species habitat may occur within area	None - No BIA defined
Tristan albatross (*Diomedea dabbenea)*	Endangered	Critically endangered	-	Species or species habitat may occur within area	None - No BIA defined
Wandering albatross (*Diomedea exulans)*	Vulnerable	Specially protected (migratory)	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA

Species	Conservation Status			Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016*	Other WA Conservation Code		
Christmas island frigatebird (*Fregata andrewsi)*	Endangered	Specially protected (migratory)	-	Foraging, feeding or related behaviour known to occur within area	None - No BIA defined
Southern giant petrel (*Macronectes giganteus)*	Endangered	Specially protected (migratory)	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Northern giant petrel (*Macronectes halli)*	Vulnerable	Specially protected (migratory)	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Abbott's booby (*Papasula abbotti)*	Endangered	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Soft-plumaged petrel (*Pterodroma mollis)*	Vulnerable	-	-	Foraging, feeding or related behaviour known to occur within area	Yes – refer to **Table 8-5**
Blue Petrel (*Halobaena caerulea)*	Vulnerable	-	-	Species or species habitat may occur within area	None - No BIA defined
Australian fairy tern (*Sternula nereis)*	Vulnerable	Vulnerable	-	Breeding known to occur within area	Yes – refer to **Table 8-5**
Indian yellow-nosed albatross (*Thalassarche carteri)*	Vulnerable	Specially protected (migratory)	-	Foraging, feeding or related behaviour may occur within area	Yes – refer to **Table 8-5**
Shy albatross (*Thalassarche cauta)*	Vulnerable	Endangered	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA
White-capped albatross (*Thalassarche cauta steadi)*	Vulnerable	Specially protected (migratory)	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA
Black-browed albatross (*Thalassarche melanophris)*	Vulnerable	Endangered	-	Species or species habitat may occur within area	None - BIA not found in EMBA

Species	Conservation Status			Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	*Biodiversity Conservation Act 2016*	Other WA Conservation Code		
Campbell albatross (*Thalassarche impavida)*	Vulnerable	Specially protected (migratory)	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Christmas Island white-tailed tropicbird (*Phaethon lepturus fulvus)*	Endangered	-	-	Species or species habitat may occur within area	None - No BIA defined

Note, only birds identified in the Protected Matters search of the EMBA, as defined in the Ningaloo Vision Operations EP have been described in the sections below.

8.2.1 Shorebirds

Red Knot (New Siberian Islands and north-eastern Siberia)

The red knot is a migratory shorebird and the species includes five subspecies, including two found in Australia, Calidris canutus piersmai and Calidris canutus rogersi. The red knot breeds in Siberia and spends the non-breeding season in Australia and New Zealand. Non breeding season is spent on tidal mudflats or sandflats where they feed on intertidal invertebrates, especially shellfish (Garnet et al. 2011).

Curlew Sandpiper

This species is a migratory shorebird that breeds in north Siberia and spends the non-breeding season from western Africa to Australia (Bamford et al. 2008). The curlew sandpiper occurs around coastal Australia and preferred habitats include coastal brackish lagoons, tidal mud and sand flats, estuaries, saltmarshes and less often inland. Their diet is mainly comprised of polychaete worms, molluscs and crustaceans (Higgins & Davies 1996 in Garnet et al. 2011).

Great Knot

The great knot is a migratory shorebird with a global distribution, breeding in north-east Siberia and spending the non-breeding season along coasts from Arabia to Australia. Non breeding birds migrate to inlets, bays, harbours, estuaries and lagoons with large intertidal mud and sand flats where they feed on bivalves, gastropods, crustaceans and other invertebrates (Higgins & Davies 1996 in Garnet et al. 2011).

Greater Sand Plover and Lesser Sand Plover

The greater sand plover and lesser sand plover are cogeners that breed in China, Mongolia and Russia. The greater sand plover spends the non-breeding season along coasts from Japan through southeast Asia to Australasia, while the lesser sand plover spends the non-breeding season along coasts from Taiwan to Australasia (Banford *et al*. 2008). Non breeding birds occur along all Australian coasts, especially in the north for the greater sand plover (DoEE 2017a) and in the east for the lesser sand plover (DoEE 2017a).

Non breeding birds forage on beaches, salt-marshes, coastal bays and estuaries, and feed on marine invertebrates including molluscs, worms, crustaceans and insects (Marchant & Higgins 1993 in Garnet *et al*. 2011).

Bar-tailed Godwit (Western Alaskan and Northern Siberian Subspecies)

Two subspecies of the bar-tailed godwit exist, as determined by their breeding locations in Siberia and Alaska (Bamford *et al*. 2008). Non-breeding birds migrate to the coasts of Australia. The western Alaskan subspecies occurs especially on the north and east coasts of Australia whilst the northern Siberian subspecies occurs especially along the coasts of north Western Australia (DoEE 2017b).

Non breeding birds are found on muddy coastlines, estuaries, inlets, mangrove-fringed lagoons and sheltered bays, feeding on annelids, bivalves and crustaceans (Higgins and Davies 1996 in Garnet *et al*. 2011).

Eastern Curlew

The eastern curlew is a migratory shorebird that breeds in Siberia, Kamchatka and Mongolia and migrates to coastal East Asia and Australia. The South Korean Yellow Sea is an important staging post for this species. Non breeding birds occur around coastal Australia, are more common in the north and have disappeared or become much rarer at many sites along the south coast (Garnet 2011).

Non breeding birds are present at estuaries, mangroves, saltmarshes and intertidal flats, particularly those with extensive seagrass (Zosteraceae), where they feed on marine invertebrates, especially crabs and small molluscs (Higgins & Davies 1996 in Garnet 2011).

Australian Painted Snipe

The Australian painted snipe has been recorded at wetlands in all states of Australia (DoE 2014h). The Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (*Melaleuca*). The Australian painted snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber (DoE 2014g).

Australasian Bittern

The Australasian bittern is found in coastal and sub-coastal areas of south-eastern and south-western mainland Australia and the eastern marshes of Tasmania (Birdlife Australia 2017). The specie lives predominantly in reedbeds and other water vegetation. Feeding on other small animals, insects, snails and spiders the bittern forages at night. Breeding occurs during summer from October to January.

White-winged Fairy Wren

The white-winged fairy wren (Barrow Island) is listed as Vulnerable under the EPBC Act. It is only found on Barrow Island (Garnett & Crowley 2000; Schodde & Mason 1999 in DEWHA, 2008), and occurs in grasslands and low shrublands. It is most common in *Triodia*-dominated habitats on shallow soil on limestone ridges and rises, but it also occurs on sand dunes in coastal and inland areas (including on sand-loam soils in valleys and on plains), and occasionally on clay pans. The bird is considered to be resident (i.e. present throughout the year) on Barrow Island (Sedgwick 1978; in DEWHA, 2008). It may also be sedentary given that, with the possible exception of a single unconfirmed record of a White-winged Fairy-wren (of unknown subspecies) on Trimouille Island in the Montebello Islands group, it has not been recorded on any nearby islands or on the mainland (Garnett & Crowley 2000; Higgins *et al*. 2001; Schodde & Mason 1999 in DEWHA, 2008).

There are no clear immediate threats to the White-winged Fairy-wren (Barrow Island) (Garnett & Crowley 2000 in DEWHA, 2008). The subspecies was considered to be vulnerable by Garnett and Crowley (2000, in DEWHA, 2008) on the basis that some of the natural features of Barrow Island, namely the narrow shape of the island and the uniformity of its habitat, make the resident population of fairy-wrens vulnerable to catastrophic events such as a severe cyclone or an extensive wildfire.

8.2.2 Seabirds

Australian Lesser Noddy

This species is usually found only around its breeding islands in the Houtman Abrolhos Islands in Western Australia (Storr *et al*. 1986). The Australian lesser noddy occupies coral-limestone islands that are densely fringed with white mangrove *Avicennia marina*, and it occasionally occurs on shingle or sandy beaches (Higgins & Davies 1996 in DoEE 2017a). This species is thought to be sedentary or resident, staying near to its breeding islands in the non-breeding season. It may leave nesting islands for short periods during the non-breeding season, and probably forages widely (Higgins & Davies 1996 in DoEE 2017a).

Breeding apparently occurs only on Morley, Wooded and Pelsaert Islands at the Houtman Abrolhos Islands (Higgins and Davies 1996 in DoE 2014b). Mangrove stands support approximately 68,000 breeding pairs spread over the three islands (Surman & Nicholson 2006). Breeding may also occur on Ashmore Reef (Stokes & Hinchey 1990). The breeding season extends from mid-August to early April (Higgins & Davies 1996 in DoE 2014b).

The National Conservation Values Atlas identifies BIAs for this species in the area of the Houtman Abrolhos islands. The National Recovery Plan for Ten Species of Seabirds 2005-2010 (DEH 2005) states that Ashmore Island could possibly be important habitat, however the Species Group Report Card – Seabirds (DSEWPaC 2012b) states that the entire Australian population of this species breeds in the South-west Marine Region, south of Busselton.

The Australian lesser noddy is listed as vulnerable under the EPBC Act. It is usually found only around its breeding islands in the Houtman Abrolhos Islands in WA (Storr *et al*., 1986) but has also been recorded on Barrow Island and Webb Island (Higgins and Davies, 1996). These birds are found on coral-limestone islands that are densely fringed with white mangrove in which it roosts, especially at night, but are also found resting on sandy and shingle beaches. They are thought to be mainly sedentary or resident and tend to stay near their breeding islands (Higgins and Davies, 1996), but may transit the Operational Area and PW mixing zone.

Albatrosses

A Protected Matters search of the waters in the EMBA (**Appendix D2 and D3**) identified several albatross species that may occur in the area, comprising of the southern royal albatross, northern royal albatross, Amsterdam albatross, Antipodean albatross, Tristan albatross, sooty albatross, wandering albatross, Indian yellow-nosed albatross, shy albatross, white-capped albatross, black-browed albatross and Campbell albatross. All these species predominantly occur in subantarctic to subtropical waters and breed on islands in the southern oceans (DoEE 2019a).

The National Conservation Values Atlas (DoEE 2019b) and the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC 2011) do not identify any BIAs for these species in the area from Busselton to the Northern Territory border. However, a BIA for the Indian yellow-nosed albatross is identified for foraging north to Shark bay and extending east into Bass Strait.

Southern Giant Petrel

The southern giant petrel is a highly migratory bird with a large natural range. This species occurs from Antarctic to subtropical waters and breeds on the Antarctic continent, peninsular and islands and on subantarctic islands and South America. Breeding occurs annually between August and March (DoEE 2017a).

The National Conservation Values Atlas (DoEE 2017b) and the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC 2011) do not identify any BIAs for this species in the area from Busselton to the Northern Territory border.

The southern giant petrel is listed as endangered and migratory under the EPBC Act. It is a highly migratory bird which has a large natural range (DoE 2013k). This species occurs in Antarctic to subtropical waters, so while this species may over-fly the Operational Area and PW mixing zone location from time-to-time in transit or for foraging, they do not use the area for breeding or resting as there are no critical nesting or feeding areas within the EMBA.

Northern Giant Petrel

The northern giant petrel occupies the Antarctic Polar Front. In summer, it occurs predominantly in sub-Antarctic to Antarctic waters, usually between 40 and 64° The northern giant-petrel breeds on sub-Antarctic islands. Its breeding range extends into the Antarctic zone at South Georgia. It nests in coastal areas where vegetation or broken terrain offers shelter, on sea-facing slopes, headlands, in the lee of banks, under or against vegetation clumps, below cliffs or overhanging rocks, or in hollows. On Campbell Island, it nests on the edge of the coastal plateau. Tussock-grass is widespread at many breeding sites. Its nests are built in secluded, coastal sites, sheltered by heavy vegetation. On Antipodes Island, it nests under *Senecio antipoda* (DoE 2014d).

The National Conservation Values Atlas (DoEE 2017b) does not identify any BIAs for this species in area spanning SW WA to the Northern Territory border.

The northern giant petrel is listed as vulnerable and migratory under the EPBC Act. It is a highly migratory bird which has a large natural range (DoE 2013j). The Northern Giant Petrel breeds in the sub-Antarctic, and visits areas off the Australian mainland mainly during the winter months (May-October) (DoE 2013j). This species may over-fly the Operational Area and PW mixing zone location from time-to-time in transit or for foraging, they do not use the area for breeding or resting as there are no critical nesting or feeding areas within the EMBAs.

Soft-Plumaged Petrel

The soft-plumaged petrel is generally found over temperate and subantarctic waters in the South Atlantic, Southern Indian and western South Pacific Oceans. The species breeds colonially on islands in the southern oceans. Breeding occurs from August to May (Marchant & Higgins 1990 in DoEE 2017a).

A BIA for this species is identified for foraging in seas north to 21°30'S off of WA.

The soft-plumaged petrel is listed as vulnerable under the EPBC Act. As a mainly sub-Antarctic species they are usually seen in cooler seas but have been noted off southeast Australia between 9.8–21°C and are widespread during winter and summer (DoE 2013l). The petrel is a marine oceanic species but occasionally occurs inland and may transit the Operational Area and PW mixing zone.

Australian Fairy Tern

The fairy tern is distributed in a large geographic range between Australia, New Zealand and New Caledonia. Three subspecies have been identified, one of which is found in Australia. The Australian fairy tern occurs along the coasts of Victoria, Tasmania, South Australia and Western Australia; occurring as far north as the Dampier Archipelago (DoEE 2017a). The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine islands, wetlands and mainland coastline (Higgins & Davies 1996 in DoE 2014b, Lindsey 1986).

Australian fairy terns nest on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The Australian fairy tern breeds from August to February depending on the location of the breeding colony (Higgins & Davies 1996 in DoEE 2017a). They generally nest in small colonies of up to 100 birds, although larger colonies of more than 1400 pairs have been reported in Western Australia (Hill *et al*. 1988).

The National Conservation Values Atlas (DoEE 2017b) identifies the vicinity of the lower north-west coast (north to Dampier Archipelago) and west coast (south to Peel inlet) as BIAs for foraging. Biologically important breeding areas were also identified scattered along the coast between Shark Bay and the Pilbara.

Christmas Island Frigatebird

The Christmas Island frigatebird is a very large seabird. Breeding colonies of the Christmas Island frigatebird is currently confined to Christmas Island in the Indian Ocean (DoE 2014c). No breeding colonies have ever been found away from Christmas Island.

Blue Petrel

The blue petrel is marine species of the Sub Antarctic and Antarctic seas. In summer, it occurs mainly over waters of -2 to 2° C in surface temperature, but it also ranges south to the edge of the pack-ice and north to approximately 30° south, or further north over cool currents (DoE 2014e). In the Antarctic, it generally avoids the pack-ice, and only occasionally approaches the edge of the ice. Given the location of the EMBA, this species is unlikely to occur.

The National Conservation Values Atlas (DoEE 2019b) does not identify any BIAs for this species in the area spanning SW WA to the NT border.

Abbott's Booby

Currently, Abbott's booby is only known to breed on Christmas Island and to forage in the waters surrounding the island (DoE 2014f). Within Christmas Island, most nests are found in the tall plateau forest on the central and western areas of the island, and in the upper terrace forest of the northern coast.

The National Conservation Values Atlas (DoEE 2019b) does not identify any BIAs for this species in the area spanning SW WA to the NT border.

Christmas Island White-tailed Tropicbird

The Christmas Island white-tailed tropicbird is endemic to Christmas Island and leaves the island to forage in the warm waters of the Indian Ocean (Garnett 2011). The white-tailed tropicbird roots at sea; only incubating or brooding adults remain on nests on the island at night (Stokes 1988).

The National Conservation Values Atlas (DoEE 2019b) does not identify any BIAs for this species within the EMBA.

Fairy Prion (southern)

The fairy prion is distributed off the cold-water coasts of Antarctica and southern Australia and New Zealand. The southern subspecies is known to breed on Macquarie Island, Langdon Point, Davis Point and Bishop and Clerk islands (Garnett & Crowley 2000). It is estimated that the population of the fairy prion (southern) is a little over 50 pairs (Brothers 1984).

The National Conservation Values Atlas (DoEE 2019b) does not identify any BIAs for this species within the EMBA.

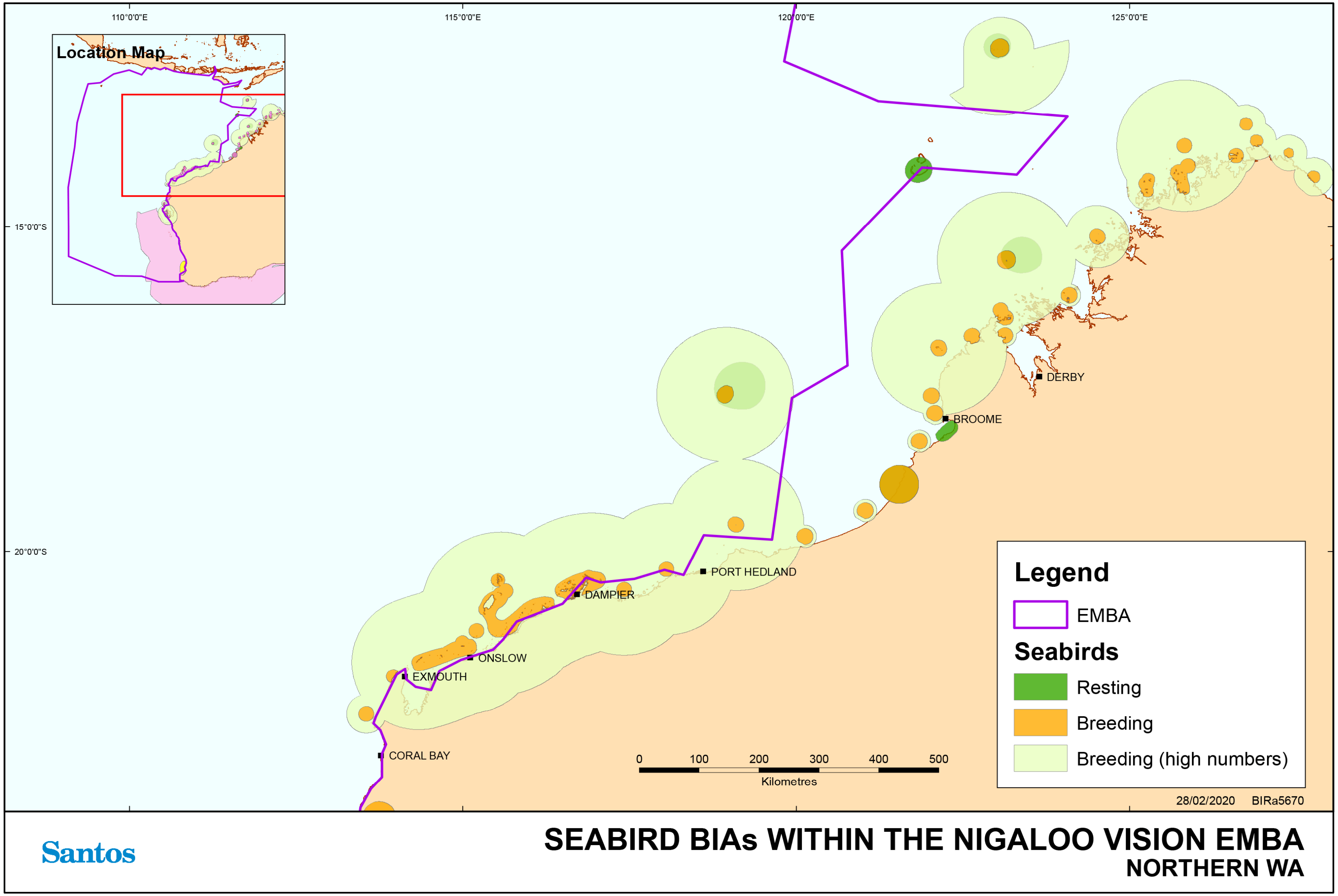

Figure 8-1: Biological important areas – birds – Northern WA

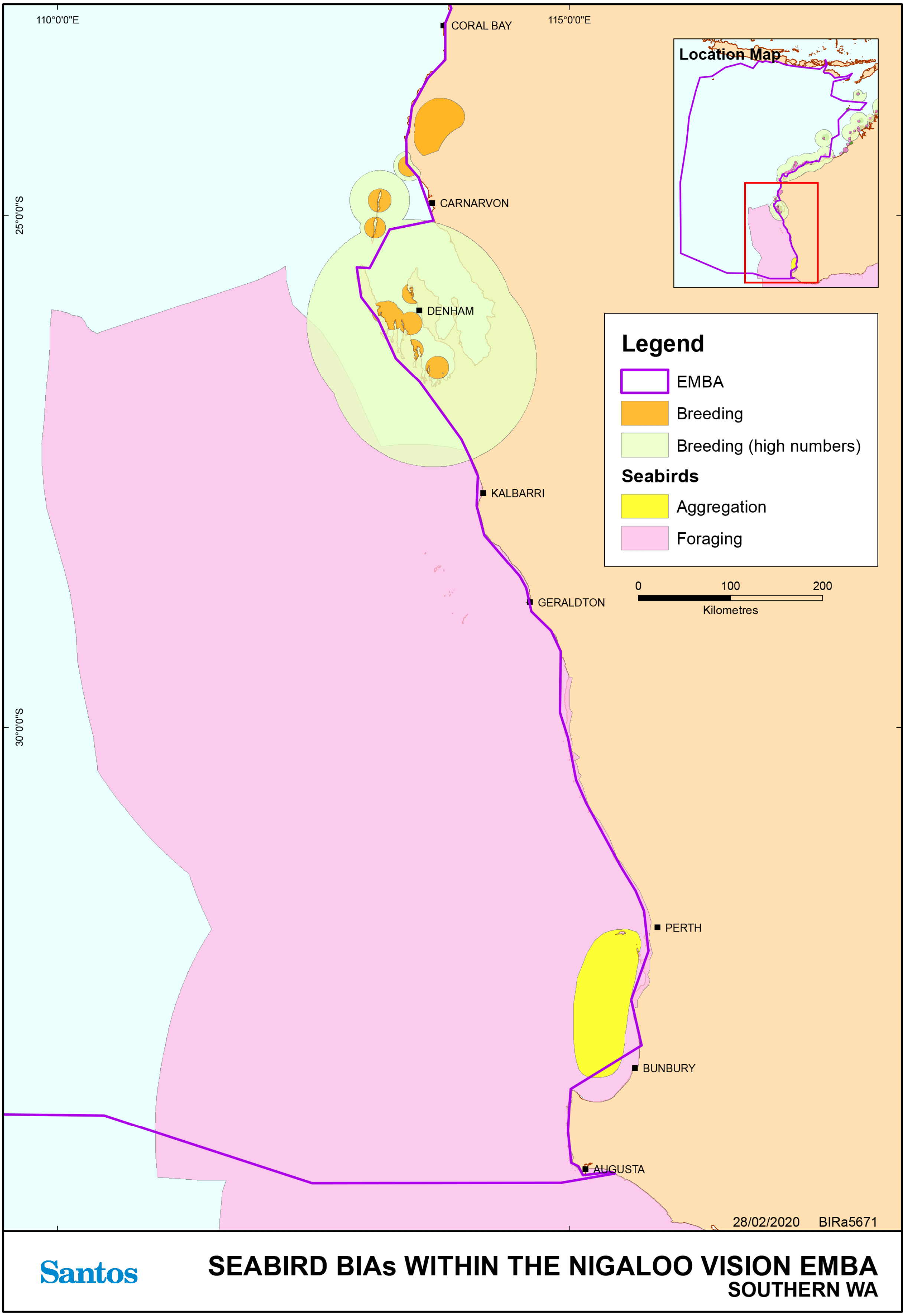

Figure 8-2: Biologically important areas – birds – Southern WA

Table 8-2: Summary of information for birds listed as threatened under the EPBC Act that may be in the EMBA.

Species	Species Expected in EMBA	Breeding in the Area /Seasonality	Foraging
Shorebirds			
Red knot	Yes	No	Intertidal invertebrates
Curlew sandpiper	Yes	No	Polychaete worms, molluscs and crustaceans taken from shorelines
Great knot	Yes	No	Bivalves, gastropods, crustaceans and other invertebrates taken from shorelines
Greater sand plover/lesser sand plover	Yes	No	Marine invertebrates taken from shorelines
Bar-tailed godwit	Yes	No	Annelids, bivalves and crustaceans taken from shorelines
Eastern curlew	Yes	No	Marine invertebrates associated with seagrass
Australasian bittern	Yes	No	Other small animals, insects, snails and spiders
Australian painted snipe	Yes	No	Seeds and small invertebrates
Western Alaskan bar-tailed godwit	Yes	No	Worms, molluscs, crustaceans, insects
Northern Siberian bar-tailed godwit	Yes	No	Worms, molluscs, crustaceans, insects and some plant material
Seabirds			
Australian lesser noddy	May forage from Kalbarri to Shark Bay	No	Small fish taken from marine and coastal waters (DoE 2014b)
Amsterdam albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Antipodean albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Black-browed albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Campbell albatross	Low densities	No	Cephalopods, fish, salps, jellyfish and crustaceans taken from marine and coastal waters.
Indian yellow-nosed albatross	Low densities	No	Cephalopods, and fish taken from marine and coastal waters.
Northern royal albatross	Low densities	No	Cephalopods, fish, salps and crustaceans taken from marine and coastal waters.
Shy albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Sooty Albatross	Low densities	No	Cephalopods, fish, crustaceans, siphonophores and penguin carrion taken from marine waters.

Species	Species Expected in EMBA	Breeding in the Area /Seasonality	Foraging
Southern royal albatross	Low densities	No	Cephalopods, and fish taken from marine and coastal waters.
Tristan albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine waters.
Wandering albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
White-capped albatross	Low densities	No	Cephalopods and fish taken from marine and coastal waters.
Southern & Northern giant petrel	Low densities	No	Scavenges penguin, seal and whale carcasses. Hunts live birds, penguin chicks' cephalopods and krill. Marine and coastal waters (DoE 2014b)
Soft-plumaged petrel	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters (DoE 2014b)
Australian fairy tern	Yes	Yes Aug to Feb	Bait fish taken from coastal waters
Fairy prion (southern)	Very low densities	No	Small pelagic crustaceans, small fish and squid
Christmas Island frigatebird	Low densities	No	Planktonic crustaceans, fish and squid
Abbott's booby	Low densities	No	Fish and squid
Blue petrel	Low densities	No	Crustaceans, small fish and squid
Christmas Island white-tailed tropicbird	Very low densities	No	Squid and flying fish

8.3 Migratory Species

Australia is signatory to three international treaties with China, Japan and the Republic of Korea to safeguard migratory bird species, predominantly shorebirds. To facilitate observance of the three agreements, 36 species of migratory shorebirds have been listed as specially protected under both the Commonwealth EPBC Act and the WA *Biodiversity Conservation Act 2016.*

Three internationally recognised areas that support shorebird migrations are protected as wetlands of international importance; Ashmore Reef, Eighty-mile Beach and Roebuck Bay. These wetlands are discussed further in **Section 9.2**.

The EPBC Act Policy Statement 3.21 sets out criteria for determining the significance of sites to migratory shorebirds based on the number of migratory species and the proportion of a species population that is supported by the site (Commonwealth of Australia 2017b). Site significance can be difficult to assess, particularly for ephemeral inland wetlands. These areas may be used rarely, depending weather conditions, but still provide important habitat for migratory shorebird species.

Migratory shorebirds require a particular conservation approach due to their migration patterns that take them across international boundaries (Bamford *et al*. 2008). These species and their habitats are sensitive to threats due to their high site fidelity, tendency to aggregate, high energy demands and the need for habitat networks containing both roosting and foraging sites (Commonwealth of Australia 2017b). Migratory shorebirds are known to use networks of connected sites (also known as site complexes). They move within these networks depending on the time of day, availability of resources and environmental conditions at the site (Commonwealth of Australia 2017b).

The types of habitat used by migratory shorebirds in Australia vary across the species identified in the PMST search. Migratory shorebirds use both coastal and inland habitats that most commonly include:

+ Coastal habitats: coastal wetlands, estuaries, mudflats, rocky inlets, reefs and sandy beaches, sometimes supporting mangroves; and
+ Inland habitats: inland wetlands, floodplains and grassland areas, often with ephemeral water sources (Commonwealth of Australia 2017b).

Feeding guilds provide an explanation for much of the shorebird distribution pattern in the north Western Australia. For example, Rogers (1999) classified shorebirds (and others) in Roebuck Bay as belonging to seven guilds on the basis of prey choice and foraging method. In order of abundance; these are summarised in Error! Not a valid bookmark self-reference..

Table 8-3: Feeding guilds based on prey choice and foraging method (Rogers 1999) adapted from DEC (2003) and Bennelongia (2008)

Feeding Habitat	Feeding Guild	Species
Sea edge	tactile hunters of macrobenthos	Great knot, red knot, bar-tailed godwit, black-tailed godwit, Asian dowitcher
Along sandy sea edges or near tidal creeks	tactile hunters of microbenthos	Curlew sandpiper, red-necked stint, broad-billed sandpiper, marsh sandpiper, sharp-tailed sandpiper
Reefs or mangrove fringes	visual hunters of slow surface-dwelling prey	Common sandpiper, sooty oystercatcher, pied oystercatcher, silver gull, ruddy turnstone
Sandier western parts of Roebuck Bay, often near-shore	visual hunters of small fast prey	Grey plover, red-capped plover, greater sand plover, lesser sand plover, grey-tailed tattler, terek sandpiper
Soft mudflats in N.E. Roebuck Bay	visual hunters of fast large prey	Eastern curlew, whimbrel, greenshank, striated heron and black-necked stork
Soft mudflats in N.E. Roebuck Bay	kleptoparasites	Gull-billed tern (robs large crabs from whimbrels)
Creek-lines in eastern Roebuck Bay	pelagic hunters of nekton (animals of the pelagic zone) and neuston (animals that live on the surface film)	Black-winged stilt, red-necked avocet, reef egret, little egret, great white egret, white-faced heron, royal spoonbill

The Wildlife Conservation Plan (DoE 2015) for Migratory Shorebirds provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia and, in recognition of their migratory habits, outlines national activities to support their appreciation and conservation throughout the East Asian-Australasian Flyway (EAAF).

The following migratory shorebird species are subject to the Wildlife Conservation Plan 2015.

Table 8-4: Birds subject to the Wildlife Conservation Plan 2015.

Migratory Species	DoAWE SPRAT information on distribution within the EMBA
Common Sandpiper	WA distribution • Roebuck Bay • Nuytsland Nature Reserve
Sharp-Tailed Sandpiper	They are widespread from Cape Arid to Carnarvon, around coastal and subcoastal plains of Pilbara Region to south-west and east Kimberley Division (Higgins & Davies 1996).
Oriental Practincole	Internationally important site • Eighty Mile Beach (2.88m birds).

	The species occurs at numerous and widespread sites in northern Australia, especially near the Pilbara and Kimberley coasts of northern Western Australia.
Oriental Plover	Internationally important marine sites • Eighty Mile Beach (~60,000 birds). • Roebuck Bay (Approximately 8500 birds)
Fork-tailed swift	In Western Australia, there are sparsely scattered records of the Fork-tailed Swift along the south coast, ranging from near the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (Higgins 1999).
Streaked Shearwater	Exmouth Gulf to the north.

Shorebird migration patterns are seasonal and vary according to species (DSEWPaC 2012). Generally, shorebirds migrate to northern Australia in August to November. Many birds remain in northern Australia but others disperse southwards (Bennelongia 2011). Migratory shorebird numbers on northern beaches peak in November then again in March as the majority of birds begin their return to the northern hemisphere between March and May. Most migratory shorebirds don't breed in Australia and juvenile birds may spend several years in Australia before reaching maturity and returning north to breed (DEWHA 2009).

8.4 Biologically Important Areas / Critical Habitat – Birds

Table 8-5 below provides an overview of BIAs in the EMBA for birds. Wedge-tailed shearwater is the only bird species to have a BIA overlap with the operational area. The DoAWE may make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[7].

In addition, both the EPBC Act and WA *Biodiversity Conservation Act 2016* and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species'. To date no critical habitat in WA has been listed under either Act.

Table 8-5: Biologically important areas - birds

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Common noddy	*Anous stolidus*	Foraging	Around Houtman Abrolhos Around Lancelin Island
Australian lesser noddy	*Anous tenuirorstris melanops*	Foraging - Houtman Abrolhos Islands	Houtman Abrolhos Islands
Flesh footed shearwater	*Ardenna carneipes*	Foraging, aggregation (pre-migration) - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Foraging from Cape Naturaliste to Eyre, 1-150 km offshore. Pre-departure zone in some years from Rottnest Island to Bunbury.
Wedge-tailed shearwater	*Ardenna pacifica*	Breeding, foraging – west coast from Ashmore Reef to Carnac I. Kimberley, Pilbara, Gascoyne coasts, Ashmore reef	Breeding (in hundreds of thousands) off west coast from Ashmore Reef (12°15'S) to Carnac Island (32°07'S), and ranging in western seas between 12°00'S and 33°20'S.

[7] Further background information on BIA and identification of critical habitat in recovery plans is provided in Section 5.3.10.

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
			Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
Little penguin	*Eudyptula minor*	Foraging - Perth to Bunbury	Perth to Bunbury
Lesser frigatebird	*Fregata ariel*	Breeding, foraging – Kimberley and Pilbara coasts and islands also Ashmore Reef.	Kimberley and Pilbara coasts and islands also Ashmore Reef.
Greater frigatebird	*Fregata minor*	Breeding, foraging - Kimberley and Ashmore Reef	Kimberley and Ashmore Reef
Caspian tern	*Sterna caspia*	Foraging - mainly islands (as far offshore as Adele, Bedout, Trimouille and the Houtman Abrolhos)	In WA found on most coasts, mainly islands (as far offshore as Adele, Bedout, Trimouille and the Houtman Abrolhos) and at Lake Argyle, Lake Gregory and Lake MacLeod; accidental elsewhere in the interior.
Pacific gull	*Larus pacificus*	Foraging –west coast and islands	West coast and islands from Point Quobba (24º30'S) south to Wedge Island (formerly south to Warnbro Sound and at Cape Naturaliste); casual further north (Point Cloates and Lake MacLeod).
Bridled tern	*Sterna anaethetus*	Foraging - West coast of Western Australia and around to Recherche Archipelago	West coast of WA and around to Recherche Archipelago including offshore waters
Sooty tern	*Sterna fuscata*	Foraging – Timor sea	Timor Sea S to 14º30, off northwest coast from Lacepede I SW to 117ºE including Abrolhos, Fisherman & Lancelin Is, accidental on lower west coast to Hamelin Bay. Breeding visitor (late Aug - early May) Abrolhos & Lancelin Is; casual winter (Nov - Apr) to Fisherman
White-tailed tropic bird	*Phaethon lepturus*	Breeding, foraging - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
Great-winged petrel	*Pterodroma macroptera*	Foraging - Offshore south of Shark Bay	Offshore south of Shark Bay, extending around south-west corner of WA and east past Kangaroo Island
Soft plumage petrel	*Pterodroma mollis*	Foraging - seas north to 21º30'S	In WA found in seas north to 21º30'S.
Little shearwater	*Puffinus assimilis*	Foraging - From Kalbarri to Eucla	From Kalbarri to Eucla including offshore waters
Roseate tern	*Sterna dougallii*	Breeding, foraging – Islands and coastline in the Kimberley, Pilbara and Gascoyne regions	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef Low Rocks and Stern Island in Admiralty Gulf North-east and North-west Twin Islets near the mouth of King sound North-western and west coasts and islands from Sir Graham Moore Is (13º50'S), south to Mandurah (32º32'S) and as far offshore as

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
			Ashmore Reef, Bedout Island and the Houtman Abrolhos.
Little tern	*Sternula albifrons*	Breeding, foraging, resting - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
Australian fairy tern	*Sternula nereis*	Foraging – Kimberley, Pilbara and Gascoyne coasts and islands	Found in the vicinity of lower north-west coast (north to Dampier Archipelago), west coast (south to Peel Inlet) and south coast (from Flinders Bay east to Israelite Bay), including islands (as far offshore as Trimouille Island and Houtman Abrolhos. Pilbara and Gascoyne coasts and islands
Brown Booby	*Sula leucogaster*	Breeding, foraging - Kimberley and northern Pilbara coasts and islands also Ashmore Reef.	Kimberley and northern Pilbara coasts and islands also Ashmore Reef.
Red-footed Booby	*Sula sula*	Breeding, foraging - north west Kimberley and Ashmore reef	North west Kimberley and Ashmore reef
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Foraging - south-west marine region, north to Shark Bay and extending east into Bass Strait	Throughout offshore waters of south-west marine region, north to Shark Bay and extending east into Bass Strait
Lesser crested tern	*Sterna bengalensis*	Breeding, foraging - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
White-faced storm petrel	*Pelagodroma marina*	Foraging (in high numbers) - Offshore areas of the south-west marine region and into the adjacent south-east marine region and the north-west marine region to north of Shark Bay	Offshore areas of the south-west marine region and into the adjacent south-east marine region and the north-west marine region to north of Shark Bay

9. Protected Areas

A number of areas in the EMBA are protected under state and federal legislation. Protected areas include World Heritage Areas (WHAs), Wetlands of International Importance (Ramsar), Wetlands of National Importance, National and Commonwealth Heritage Places, and terrestrial conservation reserves (National Parks, Nature Reserves and Conservation Parks) that bound marine waters. These areas are listed in Ningaloo Vision Operations EP and discussed below. Other protected areas include Key Ecological Features (discussed in **Section 10**) and State and Commonwealth Marine Parks/Reserves (discussed in **Section 10.1.18** and **Section 11.1.7**). A Protected Matters search of the, operational area and EMBA (**Appendix D2 and D3**) identified several protected areas which were deemed to be irrelevant to Santos WA's petroleum activities due to their terrestrial location (e.g. Forrestdale and Thomsons Lakes – Ramsar wetland).

The Register of the National Estate (RNE) provides a listing of more than 13,000 natural, historic and indigenous sites of significance. However, in 2012 all references to the RNE were removed from the EPBC Act and the *Australian Heritage Council Act 2003*.The RNE is now maintained on a non-statutory basis as a publicly available archive and educational resource. A protected matters search of the area from the South Australian border to the Northern Territory border listed 197 places on the RNE, although it is recognised that not all indigenous sites may be listed. The RNE places are not discussed further here but are listed in within the PMST searches (**Appendix D2 and D3**).

Table 3-3 of the Ningaloo Vision Operations EP provides distances from the operational area to all protected areas within the EMBA.

9.1 World Heritage Areas

There are two World Heritage Areas (WHAs) located in marine waters of WA, both of which occur in the waters from the South Australian border to the Northern Territory border: the Ningaloo Coast and Shark Bay (DEC 2012).

9.1.1 Shark Bay WHA

Shark Bay was included on the World Heritage List in 1991 and is one of the few properties inscribed for all four outstanding natural universal values:

+ An outstanding example representing the major stages in the earth's evolutionary history;
+ An outstanding example representing significant ongoing ecological and biological processes;
+ An example of superlative natural phenomena; and
+ Containing important and significant habitats for in situ conservation of biological diversity.

Since 1997, an agreement established the joint management of the Shark Bay WHA by the Australian Commonwealth government and the Western Australian state government, with the operational responsibility by the Western Australian agencies (DEWHA 2008). This agreement also created a Community Consultative Committee and a Scientific Advisory Committee, both of which provide advice as required. The entire WHA encompasses islands and peninsulas, with an area of approximately 2.2 million hectares (70% of which is marine waters), and includes the following areas (UNESCO 2014):

+ Hamelin Pool Marine Nature Reserve;
+ Francois Peron National Park;
+ Shell Beach Conservation Park;
+ Monkey Mia Reserve;
+ Monkey Mia Conservation Park;
+ Zuytdorp Nature Reserve;
+ Bernier, Dorre and Koks Islands Nature Reserves;

- Dirk Hartog Island National Park; and
- Various pastoral leases.

The marine environment of the Shark Bay WHA is protected as a State Marine Reserve and is discussed further in **Section 11.1.6**.

Shark Bay WHA is 350 km from the operational area, however it is within the EMBA.

9.1.2 The Ningaloo Coast

The Ningaloo Coast was included on the World Heritage List in 2011 and was inscribed for outstanding natural universal values as follows:

- An example of superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance;
- outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; and
- the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

The Ningaloo Coast WHA includes (DEWHA 2010):

- Ningaloo Marine Park (Commonwealth waters);
- Ningaloo Marine Park (Western Australia state waters);
- Muiron Island Marine Management Area (including the Muiron Islands);
- Jurabi Coastal Park;
- Bundegi Coastal Park;
- Cape Range National Park; and
- Learmonth Air Weapons Range.

The Ningaloo Coast World Heritage Area (including the Murion Islands) is managed under a plan that is consistent with the World Heritage Convention and Australia's World Heritage management principles. World Heritage Management principles are set out in regulations and cover matters relevant to the preparation of management plans, the environmental assessment of actions that may affect the property and community consultation processes.

The Australian World Heritage management principles are outlined under Schedule 5 of the EPBC regulations (2000). The objective is to ensure that any likely impact of an action on the World Heritage values of the property should be considered. Any action should be consistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property.

The marine environment of the Ningaloo Coast WHA is protected as a State Marine Park, a Commonwealth Marine Park, and is discussed further in **Section 11.1.1** and **Section 12.4.4**, respectively.

The Ningaloo Coast WHA is 30 km from the operational area and falls within the EMBA.

9.2 Wetlands of International Importance (Ramsar)

There are nine wetlands of international importance (Ramsar wetlands) in waters from the South Australian border to the Northern Territory border; all were listed in 1990 with the exception of Becher Point which was listed in 2001 and the ales which was listed in 2002. Three Ramsar sites exist within the EMBA. The dales (Christmas Island), Hosnies spring (Christmas Island) and Peel-Yalgorup System.

9.2.1 The Dales

The Dales are located in the Christmas Island IMCRA bioregion. It was listed as a Ramsar site on October 21st, 2002. It has an area of 583 hectares. It is located on the north western coastline of the island. It is a significant area for conservation for species of crab as well as wetland species of birds.

9.2.2 Hosnies Spring

Hosnies Spring is located on the east coast of Christmas island. It was listed as a Ramsar site on December 11th, 1990. It has an area of 202 hectares. It is home to some of the largest mangroves in the world. The area is also a protected habitat for various species of crab. Both the dales and the springs are part of Christmas Island National park and are managed by Parks Australia.

9.2.3 Peel-Yalgorup System

Peel-Yalgorup system is located along the south west coast adjacent to City of Mandurah. It was listed as a Ramsar site on June 7th 1990. It has an area of 26530 hectares. It comprises of numerous shallow estuaries, coastal saline lakes and freshwater marshes. These make up important habitats for a wide variety of waterbird species, invertebrates, estuarine and marine fish.

9.3 Wetlands of National Importance

No wetlands of national importance were identified in the operational area, PW mixing zone or EMBA.

9.4 National Heritage Places

Natural, historic and indigenous places that are of outstanding heritage value to the Australian nation are recorded as National Heritage Places. Eleven National Heritage Places are found in waters from the South Australian border to the Northern Territory border. Shark Bay and The Ningaloo Coast are listed as both World Heritage Areas and National Heritage Places.

Four National Heritage Places overlap the EMBA or have shorelines that could be contacted by oil based on results from spill modelling. These are the Ningaloo Coast and Shark Bay (described above in **Section 9.1**), the Dampier Archipelago (including Burrup Peninsula); the Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos and Dirk Hartog Landing Site 1616 – Cape Inscription Area. Information on the latter two heritage places is presented below.

9.4.1 Batavia Shipwreck site

The Batavia was included on the National Heritage List in 2006. This shipwreck is the oldest of the known Verenigde Oost-Indische Compagnie (VOC) wrecks on the WA coast and has a unique place in Australian shipwrecks. Because of its relatively undisturbed nature the archaeological investigation of the wreck itself has revealed a range of objects of considerable value to the artefact specialist and historian. The recovered sections of the hull of the Bataviathat have been reconstructed in the Western Australian Maritime Museum and provides information on 17th century Dutch ship building techniques, while the remains of the cargo carried by the vessel have provided economic, and social evidence of the operation of the Dutch port at Batavia (now Jakarta) in the early 17th century (DoE 2014d).

9.4.2 The Ningaloo Coast

See the Ningaloo Coast World Heritage Area (**Section 9.1.2**).

9.4.3 Shark Bay

See Shark Bay World Heritage Area (**Section 9.1.1**).

9.5 Commonwealth Heritage Places

The Commonwealth Heritage Places List comprises natural, indigenous and historic heritage places which are either entirely within a Commonwealth area, or outside the Australian jurisdiction and owned or leased by the

Commonwealth or a Commonwealth Authority. One natural Commonwealth Heritage Place was found in the EMBA. The Ningaloo Marine Area – Commonwealth Waters is found in Marine Parks and is discussed further in **Section 11.1.7**. The HMAS Sydney II and HSK Kormoran Shipwreck Sites is listed under both National and Commonwealth Heritage Lists and discussed in **Section14.5**.

9.5.1 Ningaloo Marine Area – Commonwealth Waters

See the Ningaloo Coast World Heritage Area (**Section 9.1.2**).

10. Key Ecological Features

10.1 Introduction

Key ecological features (KEF) are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity. KEFs meet one or more of the following criteria (DSEWPaC 2012):

+ A species, group of species or a community with a regionally important ecological role;
+ A species, group of species or a community that is nationally or regionally important for biodiversity;
+ An area or habitat that is nationally or regionally important for:
  - Enhanced or high biological productivity;
  - Aggregations of marine life; or
  - Biodiversity and/or endemism
+ A unique seafloor feature with ecological properties of regional significance.

Several key ecological features have been identified within the EMBA and operational area (**Figure 10-1** and **Figure 10-2**) and are discussed in this section.

Table 3-3 of the Ningaloo Vision Operations EP provides distances from the operational area to all KEFs within the EMBA.

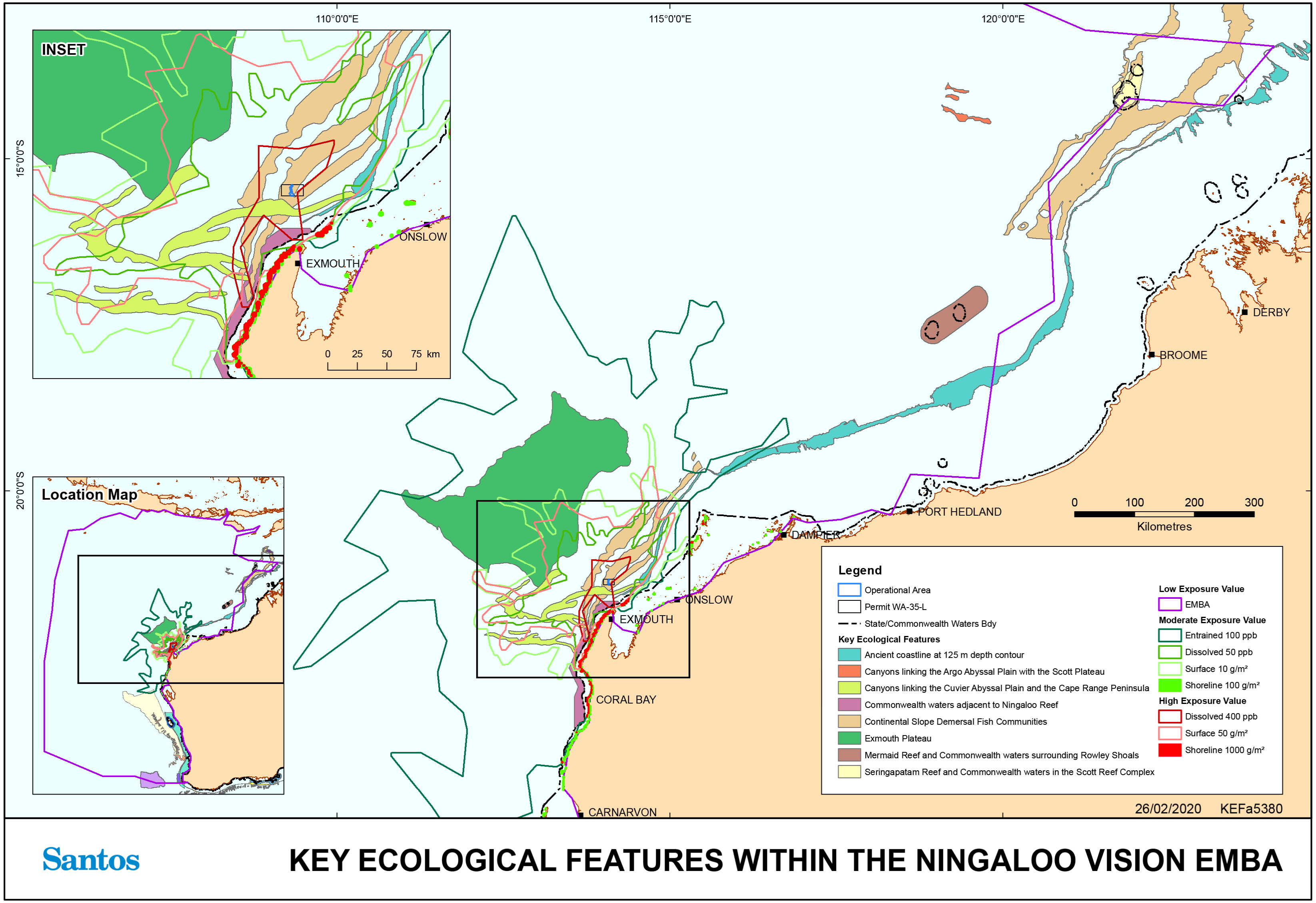

Figure 10-1: Key ecological features of Northern WA

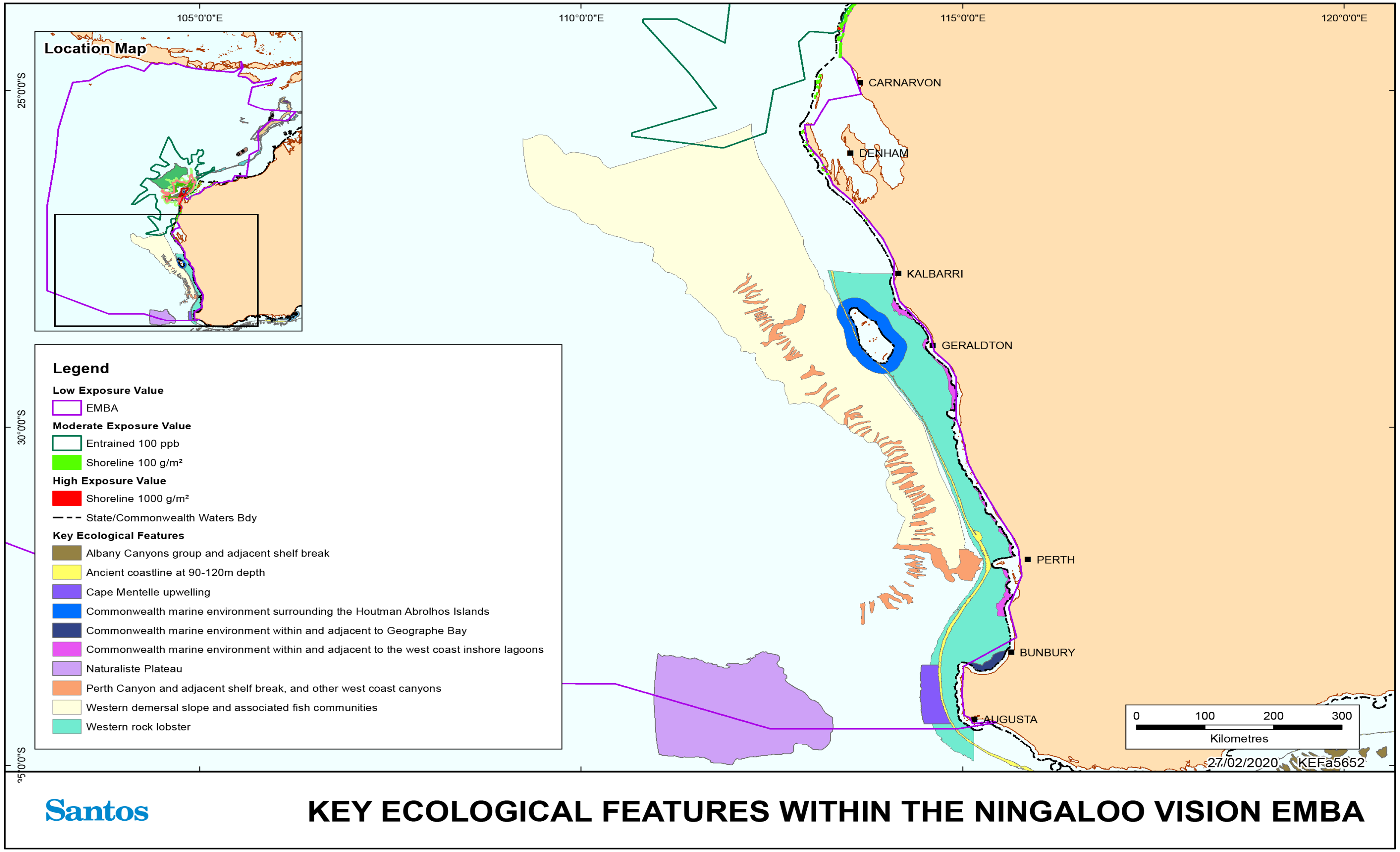

Figure 10-2: Key ecological features of Southern WA

10.1.1 Commonwealth Marine Environment Surrounding the Houtman Abrolhos Islands (and Adjacent Shelf Break)

The Commonwealth marine environment surrounding the Houtman Abrolhos Islands (and adjacent shelf break) is defined as a KEF for its high levels of biodiversity and endemism in benthic and pelagic habitats. The Houtman Abrolhos Islands and surrounding reefs support a unique mix of temperate and tropical species, resulting from the southward transport of species by the Leeuwin Current over thousands of years. The reefs are composed of 184 known species of corals that support about 400 known species of demersal fish, 492 known species of molluscs, 110 known species of sponges, 172 known species of echinoderms and 234 known species of benthic algae (DEWHA 2008b). The Houtman Abrolhos Islands are the largest seabird breeding station in the eastern Indian Ocean (DSEWPaC 2012). They support more than one million pairs of breeding seabirds. The Houtman Abrolhos Islands and surround waters are also BIAs for Australian sea lions for foraging and breeding (DEWHA 2010).

The Commonwealth marine environment surrounding the Houtman Abrolhos are 738 km from the operational area and are within the EMBA.

10.1.2 Perth Canyon and Adjacent Shelf Break, and other West-Coast Canyons

The Perth Canyon is defined as a KEF for its high biological productivity and aggregations of marine life and unique seafloor features with ecological properties of regional significance. The Perth Canyon is the largest known undersea canyon in Australian waters. In the Perth Canyon, interactions between the Leeuwin Current and the Canyon topography induce clockwise-rotating eddies that transport nutrients upwards in the water column from greater depths (DoEE 2019a). Due to the Canyon's depth and Leeuwin Current's barrier effect, this remains a subsurface upwelling which supports ecological complexity that is typically absent from canyon systems in other areas (Pattiaratchi 2007). This nutrient-rich cold-water habitat attracts feeding aggregations of deep-diving mammals, such as pygmy blue whales and large predatory fish that feed on aggregations of small fish, krill and squid (DSEWPaC 2012). The Perth Canyon also marks the southern boundary for numerous tropical species groups on the shelf, including sponges, corals, decapods and xanthid crabs (DoEE 2017a).

Perth Canyon is 721 km from the operational area and is within the EMBA.

10.1.3 Commonwealth Marine Environment within and adjacent to the West-Coast Inshore Lagoons

This key ecological feature is composed by a chain of inshore lagoons of limestone reef (as deep as 30 m) extending along the Western Australian coast from south of Mandurah to Kalbarri. The mix of sheltered and exposed seabeds form a complex mosaic of habitats. The lagoons are dominated by seagrass and epiphytic algae (Dambacher et al. 2009). Although macroalgae (principally Ecklonia spp.) and seagrass appear to be the primary source of production, scientists suggest that groundwater enrichment may supplement the supply of nutrients to the lagoons. The lagoons are associated with high biodiversity and endemism, containing a mix of tropical, subtropical and temperate flora and fauna.

The inshore lagoons are important areas for the recruitment of the commercially and recreationally important western rock lobster, dhufish, pink snapper, breaksea cod, baldchin and blue gropers, abalone and many other reef species. The area includes breeding and nursery aggregations for many temperate and tropical marine species (Goldberg & Collings 2006 in McClatchie et al. 2006). Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor and Australian salmon.

Commonwealth Marine Environment within and adjacent to the West-Coast Inshore Lagoons are 736 km from the operational area and is within the EMBA.

10.1.4 Commonwealth Marine Environment within and Adjacent to Geographe Bay

The Commonwealth marine environment within and adjacent to Geographe Bay is defined as a KEF for its high productivity and aggregations of marine life and high levels of biodiversity and endemism. Geographe Bay is known for its extensive beds of tropical and temperate seagrass that account for about 80 % of benthic primary production in the area (DEH 2006). This habitat supports a diversity of species, many of them not found anywhere else (DSEWPaC 2012). The bay provides important nursery habitat for many species, including juvenile dusky whaler sharks. It is also an important resting area for migrating for humpback whales (McCauley *et al.* 2000).

This key ecological feature is 1,339 km from the operational area and is within the south eastern corner of the EMBA.]

10.1.5 Cape Mentelle Upwelling

The Cape Mentelle upwelling is defined as a KEF for its high productivity and aggregation soft marine life. The Cape Mentelle upwelling draws relatively nutrient-rich water from the base of the Leeuwin Current, up the continental slope and onto the inner continental shelf, where it results in phytoplankton blooms at the surface. The phytoplankton blooms provide the basis for an extended food chain characterised by feeding aggregations of small pelagic fish, larger predatory fish, seabirds, dolphins and sharks (DSEWPaC 2012). The Cape Mentelle upwelling has a disproportionate influence on the overall-nutrient poor nature of the region's water.

Cape Mentelle Upwelling is 1431 km from the operational area and is within the EMBA.

10.1.6 Naturaliste Plateau

The Naturaliste Plateau is defined as a KEF for its unique seafloor feature with ecological properties of regional significance. The Naturaliste Plateau is Australia's deepest temperate marginal plateau and occurs an area where numerous water bodies and currents converge. It is also the only seafloor feature in the region that interacts with the subtropical convergence front (DoEE 2019b). Although there is very little known about the marine life of the plateau, it is speculated that the combination of its structural complexity, mixed water dynamics and relative isolation indicate that it supports deep-water communities with high species diversity and endemism (DEWHA 2008b; DSEWPaC 2012). The Plateau acts as an underwater 'biogeographical island' on the edge of the abyssal plain, providing habitat for fauna unique to these depths (Richardson et al. 2005). The Plateau is also within a deep eddy field that is thought to be associated with high productivity and aggregations of marine life (Pattiaratchi 2007). Proximity to the nearby subtropical convergence front is thought to have a significant influence on the biodiversity of the Plateau (DEWHA 2008b).

Naturaliste Plateau is 1,328 km from the operational area and is within the EMBA

10.1.7 Wallaby Saddle

The Wallaby Saddle is defined as a KEF for its high productivity and aggregations of marine life. The Wallaby Saddle is an abyssal geomorphic feature located on the upper continental slope at a depth of 4,000–4,700 m (DSEWPaC 2012). The feature connects the north-west margin of the Wallaby Plateau with the margin of the Carnarvon Terrace (Falkner *et al*. 2009 in DSEWPaC 2012). The Wallaby Saddle is situated within the Indian Ocean water mass and is thus differentiated from systems to the north that are dominated by transitional fronts or the Indonesian Throughflow (DSEWPaC 2012). Little is known about the Wallaby Saddle; however, the area is considered one of enhanced productivity and low habitat diversity (Brewer *et al*. 2007). The Wallaby Saddle is associated with historical aggregations of sperm whales (DEWHA 2008c).

Wallaby Saddle is located 508 km from the operational area and is within the EMBA.

10.1.8 Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals

Mermaid Reef and Commonwealth waters surrounding Rowley Shoals is defined as a KEF for its enhanced productivity and high species richness. The Rowley Shoals are a group of three atoll reefs—Clerke, Imperieuse and Mermaid reefs—located about 300 km north-west of Broome. Mermaid Reef lies 29 km north of Clerke and Imperieuse reefs and is totally submerged at high tide. Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals are regionally important in supporting high species richness, higher productivity and aggregations of marine life associated with the adjoining reefs themselves (Done et al. 1994). Rowley shoals contain 214 coral species and approximately 530 species of fishes (Gilmour et al. 2007), 264 species of molluscs and 82 species of echinoderms (Done et al. 1994; Gilmour et al. 2007). Both coral communities and fish assemblages differ from similar habitats in eastern Australia (Done et al. 1994).

Mermaid Reef falls under Commonwealth jurisdiction and forms the Mermaid Reef Commonwealth Marine Park. Clerke and Imperieuse reefs constitute the Rowley Shoals Marine Park, which falls under Western Australian Government jurisdiction (EA 2000). The Rowley Shoals are discussed with the Commonwealth and State Marine Park (**Sections 11.1.9** and **12.4.9**).

Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals are located 365 km north-east of the operational area and is within the EMBA.

10.1.9 Glomar Shoals

The Glomar Shoals are a submerged feature situated at a depth of 33–77 m, approximately 150 km north of Dampier on the Rowley Shelf (Falkner *et al*. 2009 in DSEWPaC 2012). They consist of a high percentage of marine-derived sediments with high carbonate content and gravels of weathered coralline algae and shells (McLoughlin & Young 1985 in DSEWPaC 2012). The area's higher concentrations of coarse material compared to surrounding areas are indicative of a high energy environment subject to strong seafloor currents (Falkner *et al*. 2009 in DSEWPaC 2012).

Biological communities found at the Glomar Shoals have not been comprehensively studied, however the shoals are known to be an important area for a number of commercial and recreational fish species such as rankin cod, brown striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish. Catch rates at the Glomar Shoals are high, indicating that the area is a region of high productivity (Falkner *et al*. 2009, Fletcher & Santoro 2009 in DSEWPaC 2012). It is unclear if the removal of non-target species due to the commercial fishing over the shoals is having an impact on its value (DSEWPaC 2012).

The Glomar Shoals are regionally important for their potentially high biological diversity and localised productivity. Biological data specific to the Glomar Shoals is limited, however the fish of the shoals are probably a subset of reef-dependent species and anecdotal evidence suggests they are particularly abundant (DSEWPaC 2012).

Glomar Shoals are located 317 km from the operational area and are within the EMBA.

10.1.10 Ancient Coastline at 90-120 m Depth

This coastline is found in the South-west Marine Region and contains several terraces and steps reflecting a gradual increase in sea level across the shelf that occurred during the Holocene. Some of these features create escarpments of distinct elevation, creating topographic complexity through the exposure of rocky substrates. The most prominent of these occurs close to the middle of the continental shelf off the Great Australian Bight at a depth of 90-120 m, which provides a complex habitat for a number of species (DSEWPaC 2012c). The area has important conservation value due to its potential for high productivity, biodiversity and aggregations of marine life. Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment of exposed hard substrates, where it is dominated by sponge communities of significant biodiversity and structural complexity (DSEWPaC 2012c). These sponge communities have been recorded to contain sponges up to one metre across, which implies that some of the sponges in this region are likely to be many decades old (DSEWPC 2012c). It has been suggested that in certain places, the area may support some demersal fish species, travelling to the upper continental slope from across the continental shelf. The transportation of fine grained sediments off shelf occurs as a physical process down to depths of approximately 120 m, and influence the benthic invertebrate communities of the Great Australian Bight (DSEWPaC 2012c). Both species richness and biomass in the area, has been associated as declining with increasing depth and percentage of fines in sediment (Ward *et al.* 2006 cited in DSEWPaC 2012c).

Ancient Coastline at 90-120 m Depth is located 697 km from the operational area and is within the EMBA.

10.1.11 Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex

Scott and Seringapatam reefs are part of a series of submerged reef platforms that rise steeply from the sea floor between the 300–700 m contours on the north-west continental slope and lie in the Timor Province (Falkner et al. 2009). Scott Reef consists of two separate reef formations, North Reef and South Reef. The total area of the key ecological feature is approximately 2,418 km². As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region.

Scott and Seringapatam 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 and spinner dolphins (Jenner et al. 2008; Woodside 2009). Whale sharks and several species of sea snakes have also been recorded in this area (Donovan et al. 2008). 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 (Guinea 2006). 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 and around 720 fish species (Woodside 2009). Corals and fish at Scott Reef have higher species diversity than the Rowley Shoals (Done et al. 1994).

Scott Reef is listed as Commonwealth Heritage Places and is discussed in **Section** Error! Reference source not found..

This key ecological feature is located 1128 km from the operational area and is within the EMBA.

10.1.12 Continental Slope Demersal Fish Communities

The Australian Continental Slope provides important habitat for demersal fish communities, characterised by high endemism and species diversity. Specifically, the continental slope between North West Cape and the Montebello Trough is the most diverse slope bioregion in Australia with more than 500 fish species, 76 of which are endemic (Last *et al*. 2005 in DSEWPaC 2012).

The Continental Slope consists of two distinct community types, associated with the upper and mid slope, 225 – 500 m and 750 – 1000 m respectively. The Timor Province and Northwest Transition bioregions are the second-richest areas for demersal fish across the entire continental slope (DSEWPaC 2012). The bacteria and fauna that is present in the system on the Continental Slope are the basis for the food web for demersal fish and higher order consumers in the system. Further information of this system has been poorly researched, though it has been suggested that it is a detritus-based system, where infauna and epifauna become prey for a range of teleost fish, molluscs and crustaceans (Brewer *et al.* 2007). The higher order consumers supported by this system are likely to be carnivorous fish, deep water sharks, large squid and toothed whales (Brewer *et al.* 2007). The pelagic production is known to be phytoplankton based, with hotspots located around oceanic reefs and islands (Brewer *et al.* 2007).

It is believed that the loss of the benthic habitat along this continental shelf region would likely lead to a decline in the species diversity and endemism that this feature is associated with (DoEE 2017e). The endemism of the region is not supported by large data sets and is scarce. It is consequently not well understood what interactions exist between the physical processes and trophic structures that lead to this high diversity of fish and the suggested presence of endemic species in the region (DoEE 2017e). Continental Slope Demersal Fish communities overlaps the operational area and the EMBA.

10.1.13 Canyons Linking the Argo Abyssal Plain with Scott Plateau

The Scott Plateau connects with the Argo Abyssal Plain via a series of canyons, the largest of which are the Bowers and Oates canyons (DSEWPaC 2012). The canyons are believed to be up to 50 million years old and excavated during the evolution of the region through sediment and water movements (DEWHA 2008d). The canyons cut deeply into the south-west margin of the Scott Plateau and act as conduits for transport of sediments from an approximate depth of 2,000–3,000 m to depths of more than 5,500 m (DSEWPaC 2012). The water masses at these depths are deep Indian Ocean water on the Scott Plateau and Antarctic bottom water on the Argo Abyssal Plain. Both water masses are cold, dense and nutrient-rich (Lyne *et al*. 2006 in DSEWPaC 2012). The high productivity of the region is believed to be led by topographically induced water movements through the canyons and the action of internal waves in these canyons as well as around islands and reefs. The canyons are therefore thought to be linked to small and periodic upwellings that enhance this biological productivity (DEWHA 2008d).

The Canyons linking the Argo Abyssal Plain and Scott Plateau are likely to be important features due to their historical association with sperm whale aggregations (DSEWPaC 2012). Historical records of whaling in the Timor region indicate that the number of sperm whales was high in the region in the past. Though current numbers are unknown, it is possible that they congregate around the canyon heads adjacent to the Scott

Plateau, encouraged by the high biological productivity, supporting stocks of their prey (DEWHA 2008d). There is anecdotal evidence that supports the idea that the Scott Plateau itself may be a breeding ground for sperm and beaked whales. It is also likely that important demersal communities occur in the canyons, as they do in the Scott Plateau supported by the localised upwelling, which in turn attract larger predatory fish, sharks and cetaceans (DEWHA 2008d).

Canyons Linking the Argo Abyssal Plain with Scott Plateau fall are 944 km from the operational area and are within the EMBA.

10.1.14 Canyons Linking the Cuvier Abyssal Plain with the Cape Range Peninsula

The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula are defined as a key ecological feature as they are unique seafloor features with ecological properties of regional significance.

Cape Range Peninsula and the Cuvier Abyssal Plain are linked by canyons, the largest of which are the Cape Range Canyon and Cloates Canyon. These two canyons are located along the southerly edge of Exmouth Plateau adjacent to Ningaloo Reef and are unique due to their close proximity to the North West Cape (DSEWPaC 2012). The Leeuwin Current interacts with the heads of the canyons to produce eddies resulting in delivery of higher nutrient, cool waters from the Antarctic intermediate water mass to the shelf (Brewer *et al*. 2007). Strong internal tides also create upwelling at the canyon heads (Brewer *et al*. 2007). Thus the canyons, the Exmouth Plateau and the Commonwealth waters adjacent to Ningaloo Reef interact to create the conditions for enhanced productivity seen in this region (Sleeman *et al*. 2007 in DSEWPaC 2012). The canyons are also repositories for particulate matter deposited from the shelf and sides of the canyons and serve as conduits for organic matter between the surface, shelf and abyssal plains (DSEWPaC 2012).

The soft bottom habitats within the canyons themselves are likely to support important assemblages of epibenthic species. Biological productivity at the head of Cape Range Canyon in particular, is known to support species aggregations, including whale sharks, manta rays, humpback whales, sea snakes, sharks, large predatory fish and seabirds. The canyons are thought to be significant contributors to the biodiversity of the adjacent Ningaloo Reef, as they channel deep water nutrients up to the reef, stimulating primary productivity (DEWHA 2008b).

Canyons Linking the Curvier Abyssal Plain with the Cape Range Peninsula are 6 km from the operational area and are within the EMBA.

10.1.15 Ancient Coastline at 125 m Depth Contour

The shelf of the North-west Marine Region contains several terraces and steps which reflect changes in sea level that occurred over the last 100,000 years. The most prominent of these features occurs at a depth of 125m as an escarpment along the North West Shelf and Sahul Shelf (DSEWPaC 2012). Where the ancient submerged coastline provides areas of hard substrate it may contribute to higher biological diversity. Little detailed knowledge is available, but the hard substrate of the escarpment is likely to support sponges, crinoids, molluscs, echinoderms (DSEWPaC 2012). It is understood that changes in topography at these depths are critical points for the generation of internal waves (Holloway *et al.* 2001 cited in DEWHA 2008b), playing a minor role in aiding localised upwelling or at least regional mixing associated with the seasonal changes in currents and winds. It is also believed that this prominent floor feature could be important as a migratory pathway for cetaceans and pelagic species such as the whale shark and humpback whale, as they move north and south between feeding and breeding grounds (DEWHA 2008b).

Parts of the ancient coastline are thought to provide biologically important habitats in areas otherwise dominated by soft sediments. The topographic complexity of these escarpments may also facilitate vertical mixing of the water column providing a relatively nutrient-rich environment for species present on the escarpment (DSEWPaC 2012). This enhanced productivity could potentially be attracting baitfish, which in turn provide food for the migratory species. The pressures of potential concern on the biodiversity value of this feature generally include ocean acidification as a result of climate change (DoEE 2017).

Ancient Coastline at 125m Depth Contour are 23 km from the operational area and within the EMBA.

10.1.16 Commonwealth Waters Adjacent to Ningaloo Reef

The Commonwealth Waters adjacent to Ningaloo Reef KEF is defined for high productivity and aggregations of marine life. The Ningaloo Reef extends almost 300 km along the Cape Range Peninsula to the Red Bluff and is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent. Commonwealth waters adjacent to the reef are thought to support the rich aggregations of marine species at Ningaloo Reef through upwellings associated with canyons on the adjacent continental slope and interactions between the Ningaloo and Leeuwin currents (Brewer *et al*. 2007, DEWHA 2008c, DSEWPaC 2012). The narrow continental shelf (10 km at its narrowest) means that the nutrients channelled to the surface via canyons are immediately available to reef species. Terrestrial nutrient input is low, hence this deep-water source is a major source of nutrients for Ningaloo Reef and therefore very important in maintaining this system (DEWHA 2008b).

The reef is known to support an extremely abundant array of marine species including over 200 species of coral and more than 460 species of reef fish, as well as molluscs, crustaceans and other reef plants and animals (DEWHA 2008b). Marine turtles, dugongs and dolphins frequently visit the reef lagoon. The Commonwealth waters around Ningaloo include areas of potentially high and unique sponge biodiversity (DEWHA 2008b). Upwellings on the seaward side support aggregations such as whale sharks and manta rays (these waters are the main known aggregation area for whale sharks in Australian waters). Humpback whales are seasonal visitors to the outer reef edge and seasnakes, sharks, large predatory fish and seabirds also utilise the reef and surrounding waters.

The Ningaloo Marine Park includes this Key Ecological Feature and is discussed in **Section 12.4.4**.

Commonwealth Waters adjacent to Ningaloo Reef are located 30 km from the operational area and within the EMBA.

10.1.17 Exmouth Plateau

The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance. The Exmouth Plateau covers an area of 49,310 km^2 and is located approximately 150 km northwest of Exmouth. The plateau ranges in water depths from 800 to 4,000 m (Heap & Harris 2008 in DSEWPaC 2012). The plateau’s surface is rough and undulating at 800–1,000 m depth. The northern margin is steep and intersected by large canyons (e.g. Montebello and Swan canyons) with relief greater than 50 m. The western margin is moderately steep and smooth and the southern margin is gently sloping and virtually free of canyons (Falkner *et al*. 2009 in DSEWPaC 2012).

The Exmouth Plateau is a regionally and nationally unique tropical deep sea plateau. It that may serve an important ecological role by acting as a topographic obstacle that modifies the flow of deep waters that generate internal tides, causing upwelling of deeper water nutrients closer to the surface (Brewer *et al.* 2007). Sediments on the plateau suggest that biological communities include scavengers, benthic filter feeders and epifauna. Whaling records from the 19th century suggest that the Exmouth Plateau may have supported large populations of sperm whales (Bannister *et al*. 2007). Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton (Brewer *et al.* 2007).

Exmouth Plateau is 68 km from the operational area and exits within the EMBA.

10.1.18 Western Demersal Slope and associated Fish Communities

The Western Demersal Slope and associated Fish Communities, also known as the Demersal Slope and associated Fish Communities of the Central Western Province, is defined as a key ecological community for its high levels of biodiversity and endemism. The western demersal slope provides important habitat for demersal fish communities, with a high level of diversity and endemism. A diverse assemblage of demersal fish species below a depth of 400 m is dominated by relatively small benthic species such as grenadiers, dogfish and cucumber fish. Unlike other slope fish communities in Australia, many of these species display unique physical adaptations to feed on the sea floor (such as a mouth position adapted to bottom feeding), and many do not appear to migrate vertically in their daily feeding habits (DSEWPaC 2012). Scientists have described 480 species of demersal fish that inhabit the slope, and 31 of these are considered endemic (DoEE 2017c).

This key ecological feature is located 490 km from the operational area and within the EMBA.

10.1.19 Western Rock Lobster

The western Rock Lobster KEF is defined due to its presumed ecological role on the West Coast Continental Shelf. This species is the dominant large benthic invertebrate in the region. The lobster plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles as they are preyed upon by octopus, cuttlefish, baldchin groper, dhufish, pink snapper, wirrah cod and breaksea cod (DEWHA 2008a, DSEWPaC 2012). The high biomass of western rock lobsters and their vulnerability to predation suggest that they are an important trophic pathway for a range of inshore species that prey upon juvenile lobsters (DEWHA 2008a).

Western Rock Lobster is 697 km from the operational area and within the EMBA.

11. State Marine Conservation Reserves

11.1 Introduction

Marine parks and reserves have been progressively established in Western Australia since 1987. The Conservation and Parks Commission (CPC) is the vesting authority for marine parks and reserves under the provisions of the Conservation and Land Management Act 1984. Parks and Wildlife, within the Department of Biodiversity, Conservation and Attractions (DBCA), is responsible for day to day management of the parks.

There are three categories of state marine conservation reserves: marine parks; marine management areas; and marine nature reserves.

Marine parks are created to protect natural features and aesthetic values while allowing recreational and commercial uses that do not compromise conservation values. There are currently sixteen marine parks within the EMBA. Table 3-3 of the Ningaloo Vision Operations EP provides distances from the operational area to all KEFS within the EMBA.

Marine parks are multiple-use reserves that cater for a wide range of activities. Within marine parks there may be four types of management zones: recreation zones: general use zones; no-take areas known as sanctuary zones; and special purpose zones.

Each marine park has a ‘management plan’ that contains strategies to protect the high value assets in the park, as well as permitted activities tables. These tables provide explicit regulatory management.

Sanctuary zones are ‘no-take' areas created primarily for conservation and scientific research and are designed to protect a particular significant ecosystem or habitat. Low-impact tourism may be permitted, but no recreational or commercial fishing, aquaculture, pearling, petroleum drilling or production is allowed.

Marine management areas provide an integrated management structure over areas that have high conservation value and intensive multiple-use. There are two marine management areas within the EMBA (described below).

There is currently only one state marine nature reserve: Hamelin Pool Nature Reserve part of the Shark Bay World Heritage Area (**Section 9.1.1**)

11.1.1 Ningaloo Marine Park

The Ningaloo Marine Park was declared in May 1987 under the National Parks and Wildlife Conservation Act 1975 (Cmlth). The Ningaloo Coast, incorporating both key marine and terrestrial values was later granted World Heritage Status in June 2011. In November 2012, the Ningaloo Marine Park (Commonwealth Waters) was renamed to be incorporated in the North-west Commonwealth Marine Reserves Network. The park covers an area of 263,343 km^2, including both State and Commonwealth waters, extending 25 km offshore.

The park protects a large portion of Ningaloo Reef, which stretches over 300 km from North West Cape south to Red Bluff. It is the largest fringing coral reef in Australia, forming a discontinuous barrier that encloses a lagoon that varies in width from 200 m to 7 km. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). The Ningaloo Marine Park forms the backbone of the nature-based tourism industry, and recreational activities in the Exmouth region. Seasonal aggregations of whale sharks, manta rays, sea turtles and whales, as well as the annual mass spawning of coral attract large numbers of visitors to Ningaloo each year (CALM 2005).

The reef is composed of partially dissected basement platform of Pleistocene marine or Aeolian sediments or tertiary limestone, covered by a thin layer of living or dead coral or macroalgae. Key features that characterise the Ningaloo Reef include (CALM 2005):

+ Over 217 species of coral (representing 54 genera);
+ Over 600 species of mollusc (clams, oysters, octopus, cuttlefish, snails);
+ Over 460 species of fish;

- Ninety-seven species of echinoderms (sea stars, sea urchins, sea cucumbers);
- Habitat for numerous threatened species, including whales, dugong, whale sharks and turtles; and
- Habitat for over 25 species of migratory wading birds listed in CAMBA and JAMBA.

11.1.2 Muiron Islands Marine Management Area

The Ningaloo Marine Park Management Plan (CALM 2005) created a MMA for the Muiron Islands, immediately adjacent to the northern end of the Park. This is managed as an integrated area together with the Ningaloo Marine Park, but its status as a MMA means that some activities, including oil and gas exploration, are still permitted under a strict environmental assessment process involving DMIRS.

The Muiron Islands, located 15 km northeast of the North West Cape comprise the North and South Muiron Islands and cover an area of 1,400 ha (AHC 2006). They are low limestone islands (maximum height of 18 m above sea level (ASL)) with some areas of sandy beaches, macroalgae and seagrass beds in the shallow waters (particularly on the eastern sides) and coral reef up to depths of 5m, which surrounds both sides of South Muiron Island and the eastern side of North Muiron Island. The Muiron Islands MMA was WA's first MMA, gazetted in November 2004. It covers an area of 28,616 ha and occurs entirely within state waters (CALM 2005).

11.1.3 Barrow Island Marine Park

The Barrow Island Marine Park covers 4,169 ha, all of which is zoned as sanctuary zone (the Western Barrow Island Sanctuary Zone) (DEC 2007). It includes Biggada Reef, an ecologically significant fringing reef, and Turtle Bay, an important turtle aggregation and breeding area (DEC 2007). Representative areas of seagrass, macroalgal and deep water habitat are also represented within the marine park (DEC 2007). Passive recreational activities (such as snorkelling, diving and boating) are permitted but extractive activities such as fishing and hunting are not.

11.1.4 Barrow Island Marine Management Area

The Barrow Island Marine Management Area (MMA) is the largest reserve within the Montebello/Barrow Islands marine conservation reserves, covering 114,693 ha (DEC 2007). The MMA includes most of the waters around Barrow Island, the Lowendal Islands and the Barrow Island Marine Park, with the exclusion of the port areas of Barrow Island and Varanus Island.

The MMA is not zoned apart from one specific management zone: the Bandicoot Bay Conservation Area. This conservation area is on the southern coast of Barrow Island and has been created to protect benthic fauna and seabirds. It includes the largest intertidal sand/mudflat community in the reserves, is known to be high in invertebrate diversity and is an important feeding area for migratory birds.

As for the other reserves in the Montebello/Barrow Islands marine conservation reserves, the Barrow Island MMA includes significant breeding and nesting areas for marine turtles and the waters support a diversity of tropical marine fauna, important coral reefs and unique mangrove communities (DEC 2007). Green, hawksbill and flatback turtles regularly use the island's beaches for breeding, and loggerhead turtles are also occasionally sighted.

11.1.5 Montebello Islands Marine Park

Montebello/Barrow/Lowendal Islands are part of a shallow submarine ridge, which extends north from the mainland near Onslow. The ridge contains extensive areas of intertidal and shallow subtidal limestone pavement surrounding the numerous, mostly small islands which are found in the region. The seabed is generally less than 5 m deep and consists of sand veneered limestone pavement with patches of fringing coral reef (DEC, 2007).

The island chain lies entirely within WA State waters, with the State-Commonwealth boundary extending out to encompass the islands and waters 3 nm west of Barrow Island and north of the Montebello Islands. These islands are protected within as marine conservation reserves: Montebello Islands Marine Park, Barrow Islands Marine Park and Barrow Island Marine Management Area.

The Montebello Islands Marine Park (58,331 ha), consists of two sanctuary zones, two recreation zones, one special purpose zone for benthic protection, eleven special purpose zones for pearling and general use zones.

The Montebello Islands comprise over 100 islands, the majority of which are rocky outcrops; rocky shore accounts for 81% of shoreline habitat (DEC 2007a).

The ecological and conservation values of the Montebello and Barrow Islands Marine Conservation Reserve (MCR) include important habitats including corals reefs and bommies, mangroves, seagrass and macroalgae meadows, rocky shorelines and hard substrate, intertidal sand and mudflat communities. These habitats provide protection, food and habitat for a large diversity of species, including dugongs, turtles, whales, other protected cetaceans and birds as well as sea snakes and fish. The area is considered to have a high biodiversity. The islands also provide feeding and resting areas for migrating shorebirds and seabird nesting areas.

Socio-economic values of the Montebello and Barrow Islands MCR include hydrocarbon exploration and production, pearling, nature-based tourism, commercial and recreational fishing, water sports, European history and maritime heritage and scientific research (DEC, 2007)

Special purpose zones for pearling are established for the existing leaseholder to allow pearling to be the priority use of these areas (DEC 2007a). Commercial fishing includes a trap fishery for reef fishes, mainly in water depths of 30–100 m, and wet lining for reef fish and mackerel. Fish trawling also occurs in the waters near to the Montebello Islands. A tourist houseboat operates out of Claret Bay, at the southern end of Hermite Island, during the winter months. The Montebello Islands are becoming more frequently used by recreational boaters for camping, fishing and diving activities.

11.1.6 Shark Bay Marine Park

The Shark Bay Marine Reserves comprise the Shark Bay Marine Park and the Hamelin Pool Marine Nature Reserve. The Shark Bay Marine Park was gazetted on 30 November 1990 as A Class Marine Park Reserve No. 7 and vested in the National Park and Nature Conservation Authority (NPNCA) under the CALM Act. The marine park encompasses an area of 748,725 ha (CALM 1996).

The Bay is located near the northern limit of a transition region between temperate and tropical marine fauna. Of the 323 fish species recorded from Shark Bay, 83% are tropical species with 11% warm temperate and 6% cool temperate species. Similarly, of the 218 species of bivalves recorded in Shark Bay, 75% have a tropical range and 10% a southern Australian range, with 15% being endemic to the west coast (CALM 1996).

Key features of Shark Bay Marine Park include (CALM 1996, DSEWPaC 2013):

+ 12 species of seagrass making it one of the most diverse seagrass assemblages in the world;
+ Seagrass that covers over 4,000 km2 of the bay. The 1,030 km2 Wooramel Seagrass Bank is the largest structure of its type in the world;
+ An estimated population of about 11,000 dugongs, one of the largest populations in the world;
+ Humpback and southern right whales use the bay as a migratory staging post;
+ Bottlenose dolphins occur in the bay, and green turtle and loggerhead turtle nest on the beaches;
+ Large numbers of sharks including whaler, tiger shark and hammerhead are present as well as an abundant population of rays, including the manta ray;
+ Hamelin Pool in Shark Bay contains the most diverse and abundant examples of stromatolite forms in the world, representative of life-forms which lived some 3,500 million years ago; and
+ Shark Bay Marine Park does not cover Bernier and Dorre Islands and only coastal waters inshore of Dirk Hartog Island (east of eastern shoreline).

Shark Bay was included on the World Heritage List in 1991 primarily on the basis of three natural features: vast seagrass beds; dugong population; and stromatolites (microbial colonies that form hard, dome-shaped deposits and are among the oldest forms of life on Earth) (DSEWPaC 2013; see **Section 9.1**).

There is no zoning within the Hamelin Pool Marine Nature Reserve. This area is a 'look but don't take' area managed solely for the conservation of globally outstanding marine life. Hamelin Pool is one of only two known places in the world with living examples of marine stromatolites (DEC 2010). The shores of Hamelin Pool are also important for the formation of extensive marine algal mats formed by microbial algae. If damaged, the mats and stromatolites can take many hundreds of years to recover (DEC 2010).

11.1.7 Ngari Capes Marine Park

The Ngari Capes Marine Park is gazetted as a Class A Marine Park. The park is located off the southwest coast of Western Australia, approximately 250 km south of Perth, covering approximately 123,790 ha. The seaward boundary of the marine park is congruent with the seaward limit of Western Australian waters (three nautical miles from the territorial baseline). The north-eastern boundary in Geographe Bay is located near the intersection of the Shire of Busselton boundary with the coastline. The Shire of Busselton–Shire of Capel boundary is approximately 30 m north-east of the marine park boundary, while the south-eastern boundary in Flinders Bay is located at 115˚17'00" E. The marine park consists of four areas that are representative of the Leeuwin–Naturaliste marine bioregion: Geographe Bay; Cape Naturaliste to Cape Mentelle coast; the Cape Mentelle to Cape Leeuwin coast; and Flinders Bay. These areas show distinct differences in geomorphology, oceanography, habitats and flora and fauna.

The Ngari Capes Marine Park was identified as one of the most diverse temperate marine environments in Australia. Warm, tropical waters of the Leeuwin Current mix with the cool waters of the Capes Current, resulting in high finfish diversity, including tropical and temperate species (see fish in **Section 5.1.1**) and internationally significant seagrass diversity with seagrasses occurring at depths greater than 40 m (see seagrasses in **Section** Error! Reference source not found.). The marine park also surrounds a number of islands that are important seabird nesting habitat and pinniped haul-outs (places where seals and sea lions leave the water and come onto land), including Hamelin Island, Sugarloaf Rock and the Saint Alouarn Islands which include Flinders Island, Seal Island and Square Rock (DEC 2013). These islands are vested with the Conservation Commission as nature reserve and are managed by DBCA for the purpose of conservation. The marine park is also adjacent to the Leeuwin Naturaliste National Park which extends to the high water mark (DEC 2013).

11.1.8 Jurien Bay Marine Park

The Jurien Bay Marine Park is a Class A marine park located on the central west coast of Western Australia about 200 km north of Perth and covers an area of 82,375 ha (CALM 2005b). Its western boundary is the seaward limit of Western Australian coastal waters. Its northern boundary is the northern point of Dynamite Bay at Green Head (30° 4' 7.9" South), and its southern boundary is located just south of Wedge (30° 50' 20" South) and is contiguous with the southern boundary of the Wanagarren Nature Reserve.

Jurien Bay Marine Park is considered to be broadly representative of the Central West Coast limestone reef system, which is a major marine ecosystem within this bioregion. The marine biota of the area consists of an unusual mix of tropical and temperate species as well as many endemic species (Larkum & Hartog, 1989). The Marine Park is dominated by five major marine habitat types: seagrass meadows; bare or sparsely vegetated mobile sand; shoreline and offshore intertidal reef platforms; subtidal limestone reefs; and reef pavement (CALM 2005b). Marine wildlife includes 14 species of cetaceans, a variety of sea and shorebirds which nest on the islands and the Australian sea lion (North Fisherman Island to the north of Jurien Bay is one of the main breeding sites for sea lions in the Central West Coast region and it is believed this breeding population is genetically distinct from the southern coast population – Gales et al. 1992). Commercial fishing for western rock lobster as well commercial wetlining, abalone, shark netting, beach seining for mullet and collecting of specimen shells and aquarium fish are carried out within the marine park.

11.1.9 Rowley Shoals Marine Park

The Rowley Shoals (including the Commonwealth-managed Mermaid Reef Marine National Nature Reserve) are located approximately 300 km west-northwest of Broome, lying between 17°07'S, 119°36'E and 17°35'S, 118°56'E and encompassing approximately 87,674 ha (DEC 2007b).

The Rowley Shoals is ecologically significant in that the reefs form part of a series of important ecological "stepping stones" for a range of reef biota originating in Indonesian/west Pacific waters. Their position off the north-west Australian coast, an area of few offshore reef systems, provides an important upstream source for recruitment to reefs further south (DEC 2007b). Marine wildlife includes 184 species of corals, primarily Indo-West Pacific species, indicating the strong affinity of the Rowley Shoals communities with Indonesia. In terms of other species, at least 264 species of molluscs, 82 species of echinoderms and 389 species of finfish were also identified (DEC 2007b). The faunal assemblages of the Rowley Shoals Marine Park are regionally significant as they contain large numbers of species not found in the more turbid coastal environments of tropical Western Australia (DEC 2007b). There is a relatively low level of recreational and commercial activity, mostly attributed to the remoteness of the Shoals with access difficult from both Indonesia and mainland Australia (DEC 2007b).

11.1.10 Marmion Marine Park

Marmion Marine Park was Western Australia's first marine park, declared in 1987 and is a multi-use reserve (CALM 2002). Marmion Marine Park is located offshore from Perth's northern suburbs, between Trigg Island and Burns Beach.

Habitats in the area include intertidal reef platforms, coastal sand beaches, a high limestone reef about 1 km from shore, Little Island and the Three Mile Reef system. Of note are complex assemblages of sea floor communities, including seagrass meadows, algal limestone pavement communities and crevice animal associations (CALM 2002).

12. Australian Marine Parks

12.1 Introduction

In agreement with the States and NT governments, the Australian Commonwealth government was committed to establish Commonwealth marine parks as a component of the National Representative System of Marine Protected Areas (DoE 2014) (See Error! Reference source not found., Error! Reference source not found. and Error! Reference source not found.). In November 2012, the Commonwealth Marine Reserves Network was proclaimed with the purpose of protecting the biological diversity and sustainable use of the marine environment (Director of National Parks 2012a). Commonwealth Marine Reserves were renamed as Australian Marine Parks (AMP) in October 2017. Six marine regions are included in the Australian Marine Parks Network, including the Coral Sea, the South-west, the Temperate East, the South-east the North and the North-west. The South-east network 10-year Management Plan came into effect on 1 July 2013. The remaining networks 10-year Management Plans were approved and came into effect on 1 July 2018.

The marine park networks pertinent to the EMBA include:

+ The South-West Marine Parks Network;
+ The North-West Marine Parks Network; and
+ The North Marine Parks Network.

The South-West Marine Parks Network comprises 14 marine parks. Six of these occur in West Australian waters in the EMBA, including:

+ Abrolhos Marine Park;
+ Jurien Marine Park;
+ Two Rocks Marine Park;
+ Perth Canyon Marine Park;
+ Geographe Marine Park; and
+ South-west Corner Marine Park;

The North-West Marine Parks Network comprises 13 marine parks. 9 of these occur in West Australian waters pertinent to the EMBA:

+ Carnarvon Canyon Marine Park;
+ Shark Bay Marine Park;
+ Gascoyne Marine Park;
+ Ningaloo Marine Park;
+ Montebello Marine Park;
+ Dampier Marine Park;
+ Argo-Rowley Terrace Marine Park;
+ Mermaid Reef Marine Park; and
+ Kimberley Marine Park.

The Northern Marine Parks Network comprises eight marine parks. However, only the Oceanic Shoals Marine Park extends across the boundary with the North-West Marine Parks Network, into the EMBA.

Table 3-3 of the Ningaloo Vision Operations EP provides distances from the operational area to all AMPs within the EMBA.

The sizes of these marine parks range from 300—152,000 km^2, and the water depths within the marine parks vary from approximately 15—1,500 m deep. The EPBC Act requires that each management plan assign an International Union for the Conservation of Nature (IUCN) category to each marine park. Additionally, the Act also allows for the management plan to divide a marine park into zones and to assign a category to each zone, which may differ from the overall category of the marine park. Zoning takes into account the purposes for which the marine parks were declared, the objectives of the relevant management plans, the values of the marine park and requirements of the EPBC Act and EPBC Regulations.

Five types of zone are represented within the North Marine Parks Network. However, it is only the Multiple Use Zone (IUCN Category VI) of the Oceanic Shoals Marine Park which extends into the EMBA.

The North-West Marine Parks Network includes six different types of zoning:

+ Sanctuary Zone (IUCN Category Ia);
+ National Park Zone (IUCN Category II);
+ Recreational Use Zone (IUCN Category IV);
+ Habitat Protection Zone (IUCN Category IV);
+ Multiple Use Zone (IUCN Category VI); and
+ Special Purpose Zone (Trawl) (VI).

The South-west Marin Parks Network includes six different types of zoning:

+ National Park Zone (IUCN Category II);
+ Habitat Protection Zone (IUCN Category IV);
+ Multiple Use Zone (IUCN Category VI);
+ Special Purpose Zone (Mining Exclusion) (IUCN Category VI);
+ Special Purpose Zone (IUCN Category VI); and
+ Special Purpose Zone (Trawl) (IUCN Category VI).

A summary of the South-West and North-West Marine Parks Networks is provided in **Table 12-1**.

12.2 South-West Marine Parks Network

The South-West Marine Parks Network is aligned to the South-West Marine Region. The network covers 508,371 km^2 and includes 14 marine parks (Director of National Parks, 2018a). Broad values of the South-west Australian Marine Parks include:

+ Natural values;
+ Cultural values;
+ Heritage values; and
+ Socio-economic values.

Further detail on each of the relevant marine parks those that fall within the EMBA is provided below.

12.3 South-West Marine Parks Network

The South-West Marine Parks Network is aligned to the South-West Marine Region. The network covers 508,371 km^2 and includes 14 marine parks (Director of National Parks, 2018a). Broad values of the South-west Australian Marine Parks include:

+ Natural values;

- Cultural values;
- Heritage values; and
- Socio-economic values.

Further detail on the relevant marine fall within the EMBA is provided below.

12.3.1 Abrolhos Marine Park

The Abrolhos Marine Park (including zones within the area of interest: Marine National Park Zone – IUCN Category II-2,548 km^2; Habitat Protection Zone – IUCN Category VI-23,239 km^2; Multiple Use Zone – IUCN Category VI-56,545 km^2; Special Purpose Zone – IUCN Category VI-5,729 km^2) covers an area of approximately 88,060 km^2 and protects the following conservation values (Director of National Parks, 2018a):

- Important foraging areas for the:
  - Threatened Australian lesser noddy;
  - Northernmost breeding colony of the threatened Australian sea lion;
  - Great white sharks; and
  - Migratory common noddy, wedge-tailed shearwater, bridled tern, Caspian tern and roseate tern.
- Important migration habitat for the protected humpback whale and pygmy blue whales;
- The second largest canyon on the west coast, the Houtman Canyon;
- Examples of the northernmost ecosystems of the Central Western Province and South-west Shelf Transition (including the Central West Coast meso-scale bioregion);
- Examples of the deeper ecosystems of the Abrolhos Islands meso-scale bioregion;
- Examples of the shallower, southernmost ecosystems of the Central Western Shelf Province provincial bioregion including the Zuytdorp meso-scale bioregion;
- Examples of the deeper ecosystems of the Central Western Transition provincial bioregion;
- Examples of diversity of seafloor features including: southern most banks and shoals of the North-west region; deep holes and valleys; slope habitats; terrace and shelf environments; and
- Seven key ecological features.

The Abrolhos Marine Park is adjacent to the Shark Bay World Heritage Property. The marine park does not contain any Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains 11 known shipwrecks listed under the *Historic Shipwrecks Act 1976*[8]. Commercial tourism, fishing, recreation and mining are important supported socio-economic activities in the park.

12.3.2 Jurien Marine Park

The Jurien Marine Park (including zones within the EMBA): Marine National Park Zone -IUCN Category II – 31 km^2 Special Purpose Zone -IUCN Category VI – 1,820 km^2) covers an area of approximately 1,851 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Threatened Australian sea lion;

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[8] Note that the *Underwater Culture Heritage Act 2018* has been passed on 24 August 2018, however it has yet to commence, due to commence prior to 24 August 2019.

- Threatened white shark; and
- Migratory roseate tern, bridled tern, wedge-tailed shearwater, and common noddy.

+ Important migration habitat for the protected humpback whale;
+ Examples of the ecosystems of two provincial bioregions: the central part of the South-west Shelf Transition (which includes the Central West Coast meso-scale bioregion) and small parts of the Central Western Province;
+ Three KEFs; and
+ Heritage values represented by the SS Cambewarra and Oleander historic shipwreck.

The Jurien Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, recreation and mining are important supported socio-economic activities in the park.

12.3.3 Two Rocks Marine Park

The Two Rocks Marine Park (including zones within the EMBA): Multiple Use Zone - IUCN Category VI – 867 km^2; Marine National Park Zone - IUCN Category II – 15 km^2) covers an area of approximately 882 km^2 and protects the following conservation values (Director of National Parks 2018a):

+ Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Threatened Australian sea lion; and
  - Migratory roseate tern, bridled tern, Caspian tern, wedge-tailed shearwater, and common noddy.
+ Important migratory areas for protected humpback whales and pygmy blue whales;
+ Seasonal calving habitat for the threatened southern right whale;
+ Examples of the ecosystem of the southernmost parts of the South-west Shelf Transition (including the Central West Coast meso-scale bioregion); and
+ Three KEFs.

The Two Rocks Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, recreation and scientific research are important supported socio-economic activities in the park.

12.3.4 Perth Canyon Marine Park

Perth Canyon Marine Park (including zones within the EMBA): Marine National Park Zone – IUCN Category II – 1,241 km^2; Habitat Protection Zone – IUCN Category IV –4,352 km^2; Multiple Use Zone – IUCN Category VI – 1,816 km^2) covers an area of approximately 7,409 km^2 and protects the following conservation values (Director of National Parks 2018a):

+ Globally important seasonal feeding aggregation for the threatened blue whale;
+ Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Migratory sperm whale; and
  - Migratory wedge-tailed shearwater.
+ Important migratory areas for protected humpback whales and blue whales;
+ Seasonal calving habitat for the threatened southern right whale;

- Examples of the ecosystems of the southernmost parts of the Central Western Province and South-west Shelf Transition (including the Central West Coast meso-scale bioregion), and the northernmost parts of the South-west Transition and Southwest Shelf Province (including the Leeuwin-Naturaliste meso-scale bioregion); and
- Four KEFs.

The Perth Canyon Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, shipping, recreation and defence training are important supported socio-economic activities in the park.

12.3.5 Geographe Marine Park

Geographe Marine Park (including zones within the EMBA): Marine National Park Zone - IUCN Category II – 15 km^2; Special Purpose Zone - IUCN VI – 650 km^2; Multiple Use Zone - IUCN Category VI – 291 km^2; Habitat Protection Zone (IV) 21 km^2) covers an area of approximately 977 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important foraging areas for the:
  - Threatened soft-plumaged petrel; and
  - Migratory wedge-tailed shearwater.
- Important pre-migration aggregation area for the migratory flesh-footed shearwater;
- Important migratory habitat for the protected humpback whale and blue whale;
- Seasonal calving habitat for the threatened southern right whale.
- Seasonal calving habitat for the threatened southern right whale.
- Representation of the South-west Shelf Province on the continental shelf as well as the Leeuwin-Naturaliste meso-scale bioregion;
- Two KEFs; and
- Representation of the seagrass habitats of the Geographe Bay key ecological feature, which in this location extend the furthest into Commonwealth waters.

The Geographe Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains eight known shipwrecks listed under the *Underwater Culture Heritage Act 2018.* Commercial tourism, fishing and recreation are important supported socio-economic activities in the park.

12.3.6 South-west Corner Marine Park

The South-west Corner Marine Park (including zones within the EMBA: Marine National Park Zone - IUCN II – 54,841 km^2; Multiple Use Zone - IUCN VI –106,602 km^2; Special Purpose Zone (Mining exclusion) - IUCN VI – 9,550 km^2, Special Purpose Zone – IUCN VI – 5753 km^2; Habitat Protection Zone - IUCN IV – 95,088 km2) covers an area of approximately 271,833 km2 within the EMBA and protects the following conservation values (Director of National Parks 2018a):

- Important migratory area for protected humpback whales and blue whales;
- Important foraging areas for the:
  - Threatened white shark;
  - Threatened Australian sea lion;
  - Threatened Indian Yellow-nosed albatross and soft-plumaged petrel;
  - Sperm whale;

- Migratory flesh-footed shearwater, short-tailed shearwater and Caspian tern; and
- Seasonal calving habitat for the threatened southern right whale.

+ Representation of three provincial bioregions (the South-west Transition and Southern Province in the off-shelf area, and the South-west Shelf Province on the continental shelf) and two meso-scale bioregions (southern end of the Leeuwin-Naturaliste meso-scale bioregion and western and central parts of the Western Australia South Coast meso-scale bioregion);
+ Representation of the Donnelly Banks, east of Augusta, characterised by higher productivity and including nursery habitats; and
+ Six KEFs.
+ The South-west Corner Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains ten known shipwrecks listed under the *Underwater Culture Heritage Act 2018* . Commercial tourism, fishing, shipping and recreation are important supported socio-economic activities in the park.

12.4 North-West Marine Park Network

The North-West Marine Parks Network is aligned to the North-west Marine Region. The network covers 335, 341 km^2 and includes 13 marine parks (Director of National Parks, 2018b). Broad values of the North-west Commonwealth Marine Reserves Network include:

+ Natural values;
+ Cultural values;
+ Heritage values; and
+ Socio-economic values.
+ Further detail on each of the relevant marine parks within the EMBA is provided below.

12.4.1 Carnarvon Canyon Marine Park

The Carnarvon Canyon Marine Park (Habitat Protection Zone – IUCN Category IV) covers an area of approximately 6,177 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ The Carnarvon Canyon a single channel canyon with seabed features that include slope, continental rise and deep holes and valleys;
+ The Carnarvon Canyon ranges in depth from 1500 m to over 5,000 m, thereby providing habitat diversity for benthic and demersal species; and
+ Central Western Transition provincial bioregion ecosystem examples are found here, which are characteristic of the biogeographic faunal transition between tropical and temperate species.
+ There is limited information about species' use of this Marine Park (Director of National Parks 2017b). The marine park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018b). Commercial fishing, tourism, shipping and mining are important supported socio-economic activities in the marine park.

12.4.2 Shark Bay Marine Park

The Shark Bay Marine Park (Multiple Use Zone – IUCN Category VI) covers an area of approximately 7,443 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging areas adjacent to important breeding areas for several species of migratory seabirds;
+ Part of the migratory pathway of protected humpback whales;

- Internesting habitat for marine turtles;
- Waters that are adjacent to the largest nesting area for loggerhead turtles in Australia;
- Marine park and adjacent coastal areas important for shallow-water snapper;
- Protection to shelf and slope habitats as well as a terrace feature;
- Examples of the shallower ecosystems of the Central Western Shelf Province and Central Western Transition provincial bioregions including the Zutydorp meso-scale bioregion; and
- Connectivity between the inshore waters of the Shark Bay World Heritage Area and the deeper waters of the area.

Whilst no listed international, Commonwealth or National Heritage places are within the marine park, the park is adjacent to Shark Bay World Heritage Area (Director of National Parks 2018b). Commercial tourism, fishing, mining and recreation are important socio-economic values of the park.

12.4.3 Gascoyne Marine Park

The Gascoyne Marine Park (Multiple Use Zone – IUCN Category VI-33,652 km^2; Habitat Protection Zone – IUCN Category IV-38,982 km^2; Marine National Park Zone – IUCN Category II-9,132 km^2) covers an area of approximately 81,766 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important foraging areas for: migratory seabirds threatened and migratory hawksbills and flatback turtles; and vulnerable and migratory whale shark;
- A continuous connectivity corridor from shallow depths around 15 m out to deep offshore waters on the abyssal plain at over 5,000 m in depth;
- Seafloor features including canyon, terrace, ridge, knolls, deep hole/valley and continental rise. It also provides protection for sponge gardens in the south of the reserve adjacent to Western Australian coastal waters;
- Ecosystems examples from the Central Western Shelf Transition, the Central Western Transition and the Northwest province provincial bioregions as well as the Ningaloo meso-scale bioregion;
- Four key ecological features for the region:
    - Canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula (enhanced productivity, aggregations of marine life and unique sea-floor feature);
    - Exmouth Plateau (unique sea-floor feature associated with internal wave generation);
    - Continental slope demersal fish communities (high species diversity and endemism – the most diverse slope bioregion in Australia with over 500 species found with over 64 of those species occurring nowhere else); and
    - Commonwealth waters adjacent to Ningaloo Reef.
- The canyons in this reserve are believed to be associated with the movement of nutrients from deep water over the Cuvier Abyssal Plain onto the slope where mixing with overlying water layers occurs at the canyon heads. These canyon heads, including that of Cloates Canyon, are sites of species aggregation and are thought to play a significant role in maintaining the ecosystems and biodiversity associated with the adjacent Ningaloo Reef; and
- The reserve therefore provides connectivity between the inshore waters of the existing Ningaloo Commonwealth marine park and the deeper waters of the area.

The park is also adjacent to World Heritage listings associated with the Ningaloo Coast. Commercial tourism, commercial fishing, mining and recreation are important socio-economic values of the park (Director of National Parks 2018b).

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12.4.4 Ningaloo Marine Park

Ningaloo Marine Park stretches approximately 300 km along the west coast of the Cape Range Peninsula and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park (Director of National Parks, 2018b). Ningaloo Reef is the longest fringing barrier reef in Australia forming a discontinuous barrier that encloses a lagoon that varies in width from 200 m to 7 km. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). It is the only example in the world of extensive fringing coral reef on the west coast of a continent.

The Ningaloo Marine Park (Recreational Use Zone – IUCN Category II) covers an area of approximately 2,435 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important habitat (foraging areas) for vulnerable and migratory whale sharks;
- Areas used for foraging by marine turtles adjacent to important internesting sites;
- Part of the migratory pathway of the protected humpback whale;
- Foraging and migratory pathway for pygmy blue whales;
- Breeding, calving, foraging and nursing habitat for dugong;
- Shallow shelf environments which provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features;
- Seafloor habitats and communities of the Central Western Shelf Transition;
- Three key ecological features; and
- The Ningaloo Coast World Heritage Property, the Ningaloo Coast National Heritage listing and Ningaloo Marine Area Commonwealth Heritage Listing.

Commercial tourism and recreation are important socio-economic values of the marine park (Director of National Parks 2018b).

12.4.5 Montebello Marine Park

The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western Australian state water boundary, and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks. The Montebello Marine Park (Multiple Use Zone – IUCN Category VI) covers an area of approximately 3,413 km^2 and protects the following conservation values (Director of National Parks 2018b):

- Foraging areas for migratory seabirds that are adjacent to important breeding areas;
- Areas used by vulnerable and migratory whale sharks for foraging;
- Foraging areas marine turtles which are adjacent to important nesting sites;
- Section of the north and south bound migratory pathway of the humpback whale;
- Shallow shelf environments with depths ranging from 15–150 m which provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features;
- Seafloor habitats and communities of the Northwest Shelf Province provincial bioregions as well as the Pilbara (offshore) meso-scale bioregion; and
- One key ecological feature for the region is the ancient Coastline (a unique seafloor feature that provides areas of enhanced biological productivity).

Commercial tourism, commercial fishing, mining and recreation are important socio-economic values for the park.

12.4.6 Dampier Marine Park

The Dampier Marine Park (Marine National Park Zone – IUCN Category I-73 km^2; Habitat Protection Zone – IUCN Category IV-104 km^2; Multiple Purpose Zone – IUCN Category VI-1,074 km^2) covers an area of approximately 1,252 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging areas for migratory seabirds that are adjacent to important breeding grounds;
+ Important foraging areas for marine turtles adjacent to significant nesting sites;
+ Part of the migratory pathway of the protected humpback whale;
+ Protection for offshore shelf habitats and shallow shelf habitats adjacent to the Dampier Archipelago; and
+ Communities and seafloor habitats of the Northwest Shelf Province provincial bioregion as well as the Pilbara (nearshore) and Pilbara (offshore) meso-scale bioregions are included.

Port activities, commercial fishing and recreation are important activities in the marine park (Director of National Parks 2018b). No heritage listings apply to the marine park.

12.4.7 Eighty Mile Beach Marine Park

The Eighty Mile Beach Marine Park (Multiple Use Zone – IUCN Category VI) is adjacent to the Western Australia Eighty Mile Beach Marine Park, 74 km north-east of Port Hedland and covers an area of approximately 10,785 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Breeding, foraging and resting habitat for seabirds (one of the world's most important feeding grounds for migratory shorebirds and waders and is listed under the Ramsar Convention);
+ Internesting and nesting habitat for marine turtles (it supports a significant nesting population of flatback turtles, which are endemic to northern Australia);
+ Foraging, nursing and pupping habitat for sawfish;
+ Migratory pathway for humpback whales;
+ Coastal waters provide critical habitat for several shark and ray species at varying life stages;
+ The Nyangumarta, Karajarri and Ngarla people's sea country extends into Eighty Mile Beach Marine Park. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities; and
+ Three known shipwrecks listed under the *Underwater Cultural Heritage Act 2018*: Lorna Doone (wrecked in 1923), Nellie (wrecked in 1908), and Tifera (wrecked in 1923).

+ Tourism, commercial fishing, pearling and recreation are important activities in the Marine Park (Director of National Parks 2018b).

12.4.8 Argo-Rowley Terrace Marine Park

The Argo-Rowley Marine Park is located approximately 270 km north-west of Broome, Western Australia, and extends to the limit of Australia's exclusive economic zone. The Marine Park (Multiple Use Zone – IUCN Category VI-108,812 km^2; Marine National Park Zone – IUCN Category II-36,050 km^2; Special Purpose Zone – IUCN Category VI-1,141 km^2) covers an area of approximately 146,003 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging areas that are important for migratory seabirds as well as the endangered loggerhead turtle;
+ Important habitat and foraging for sharks;
+ Migratory pathway for pygmy blue whales (Director of National Parks 2018b);
+ Protection for communities and habitats of the deeper offshore waters (220 m to over 5,000 m) of the region;
+ Seafloor features including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope;

- Communities and seafloor habitats of the Northwest Transition and Timor Province provincial bioregions;
- Connectivity between the existing Mermaid Reef Marine National Nature Reserve and reefs of the Western Australian Rowley Shoals Marine Park and the deeper waters of the region;
- Two KEFs in the reserve include:
  - The canyons linking the Argo Abyssal Plain with the Scott Plateau (unique seafloor feature with enhanced productivity and feeding aggregations of species); and
  - Mermaid Reef and the Commonwealth waters surrounding Rowley Shoals (an area of high biodiversity with enhanced productivity and feeding and breeding aggregations).

No heritage listings apply to this marine park (Director of National Parks 2018b). Commercial fishing, mining and recreation are important socio-economic values for the park.

12.4.9 Mermaid Reef Marine Park

The Mermaid Reef Marine Park (Multiple Use Zone – IUCN Category VI) lays approximately 280 km north-west of Broome, Western Australia, adjacent to the Argo–Rowley Terrace Marine Park and approximately 13 km from the Western Australian Rowley Shoals Marine Park. It covers an area of 540 km² and protects the following conservation values (Director of National Parks 2018b):

- Mermaid Reef and Commonwealth waters surrounding Rowley Shoals are valued for its high productivity, aggregations of marine life and high species richness;
- Mermaid Reef, Clerke Reef and Imperieuse Reef are biodiversity hotspot and key topographic feature of the Argo Abyssal Plain;
- Rowley Shoals present some of the best geological examples of shelf atolls in Australian waters, and are ecologically significant in that they are considered ecological steppingstones for reef species originating in Indonesian/Western Pacific waters, are one of a few offshore reef systems on the north-west shelf, and may also provide an upstream source for recruitment to reefs further south;
- Breeding habitat for seabirds;
- Migratory pathway for the pygmy blue whale; and
- One known shipwreck listed under the Underwater Cultural Heritage Act 2018: Lively (wrecked in 1810).
- Tourism, recreation, and scientific research are important activities in the Marine Park (Director of National Parks 2018b).

12.4.10 Kimberley Marine Park

The Kimberley Marine Park (Multiple Use Zone – IUCN Category VI) is located approximately 100 km north of Broome, Western Australia, and extends from the Western Australian state water boundary north from the Lacepede Islands to the Holothuria Banks offshore from Cape Bougainville. It is adjacent to the Western Australian Lalanggarram / Camden Sound Marine Park and the North Kimberley Marine Park. It covers an area of 74,469 km², and protects the following conservation values (Director of National Parks 2018b):

- Northwest Shelf Province;
  - Diverse benthic and pelagic fish communities
  - Ancient coastline thought to be an important seafloor feature
  - Migratory pathway for humpback whales
- Northwest Shelf Transition;
  - High levels of species diversity
  - Endemism occur among demersal fish communities on the continental slope
- Timor Province;
  - Reefs and islands of the bioregion are regarded as biodiversity hotspots
  - Endemism in demersal fish communities of the continental slope is high (two distinct communities have been identified on the upper and mid slopes)

- Ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitats in areas otherwise dominated by soft sediments;
- Continental slope demersal fish communities characterised by high diversity of demersal fish assemblages;
- breeding and foraging habitat for seabirds;
- Internesting and nesting habitat for marine turtles;
- Breeding, calving and foraging habitat for inshore dolphins;
- Calving, migratory pathway and nursing habitat for humpback whales;
- Migratory pathway for pygmy blue whales;
- Foraging habitat for dugong and whale sharks;
- The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul people's sea country extends into the Kimberley Marine Park. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities; and
- More than 40 known shipwrecks listed under the *Underwater Cultural Heritage Act 2018*.

+ Tourism, commercial fishing, mining, recreation, including fishing, and traditional use are important activities in the Marine Park (Director of National Parks 2018b).

Table 12-1 Summary of marine network values, pressures, management programs and actions applicable to the EMBA

Marine network	Values	Pressures	Management programs and actions
SOUTH WEST	• Nine bioregions • Key ecological features • EPBC listed species • Biologically important areas • Sea country indigenous values • Historic shipwrecks • Adjacent to Shark Bay World Heritage Area • Shipping and port activities • Commercial fishing • Marine tourism	• Climate change • Hydrological changes from coastal development and agriculture (increase sediment loads and pollutants) • Illegal/unregulated/unreported fishing • Bycatch of non-target species • Habitat modification from mining • Human presence • Invasive species • Marine pollution	• Communication, education and awareness programs • Promote suitable tourism experience • Facilitate partnerships between tourism operators and Indigenous operators • Indigenous engagement program • Marine monitoring programs • Park management via assessments / authorisation program for marine park activities • Marine park management and development of suitable infrastructure • Compliance planning and surveillance

NORTH WEST	• Eight bioregions • Key ecological features • EPBC listed species • Biologically important areas • Sea country indigenous values • Native title determinations • Traditional Indonesian fishers • World Heritage Properties (Ningaloo Coast, Shark Bay) • Ashmore Reef Marine Park and Eighty-Mile Beach Ramsar sites • Shipping and port activities • Commercial fishing, pearling, aquaculture • Marine tourism • Scientific research	• Climate change • Hydrological changes from coastal development and agriculture (increase sediment loads and pollutants) • Illegal/unregulated/unreported fishing • Bycatch of non-target species • Habitat modification from mining • Human presence • Invasive species • Marine pollution	• Communication, education and awareness programs • Promote suitable tourism experience • Facilitate partnerships between tourism operators and Indigenous operators • Indigenous engagement program • Marine monitoring programs • Park management via assessments / authorisation program for marine park activities • Marine park management and development of suitable infrastructure • Compliance planning and surveillance

13. Conservation Management Plans

In order to protect, maintain and enhance recovery of certain threatened species and ecological communities the DoAWE (formally DoEE) may prepare conservation management plans in the form of Conservation Advice or Recovery Plans.

13.1 Conservation Advice

When a native species or ecological community is listed as threatened under the EPBC Act, conservation advice is developed to assist its recovery. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of a newly listed species or ecological community.

13.2 Recovery Plans

The Australian Government Minister for the Environment may make or adopt and implement recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the Commonwealth EPBC Act. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long-term survival in the wild of a threatened species or ecological community.

Table 3-8 of the Ningaloo Vision Operations EP provides Threats and strategies from Recovery Plans, Conservation Advice and Management Plans relevant to the activity.

14. Social, Economic and Cultural Features

14.1 Industry

Section 3.2.5.1 of the Ningaloo Vision Operations EP provides details of industry within proximity to the operational area, PW mixing zone and EMBA.

14.2 Shipping

Section 3.2.5.2 of the Ningaloo Vision Operations EP provides details of shipping within proximity to the operational area, PW mixing zone and EMBA.

14.3 Defence Activities

Key defence bases and facilities are illustrated in **Figure 14-1.**

The Naval Communication Station Harold E. Holt is located on the northwest coast of Australia, 6 km north of Exmouth. The town of Exmouth was built at the same time as the communications station to provide support to the base and to house dependent families of US Navy personnel (Shire of Exmouth 2014, DoE 2014).

The station provides very low frequency (VLF) radio transmission to US Navy and Royal Australian Navy ships and submarines in the western Pacific Ocean and eastern Indian Ocean. With a transmission power of 1 megawatt, it is the most powerful transmission station in the southern hemisphere (Shire of Exmouth 2014, DoE 2014).

Two Royal Australian Airforce (RAAF) bases are located in the northwest of Western Australia; Learmonth RAAF Base, near Exmouth and Curtin RAAF Base near Derby (RAAF 2014).

Designated military exercise areas occur over waters and airspace of the north west of Western Australia and may be activated following the required notifications.

The airspace above the proposed activity location lies within a designated military exercise area. When activated by a Notice to Airmen (NOTAM), the restricted airspace can operate down to sea level.

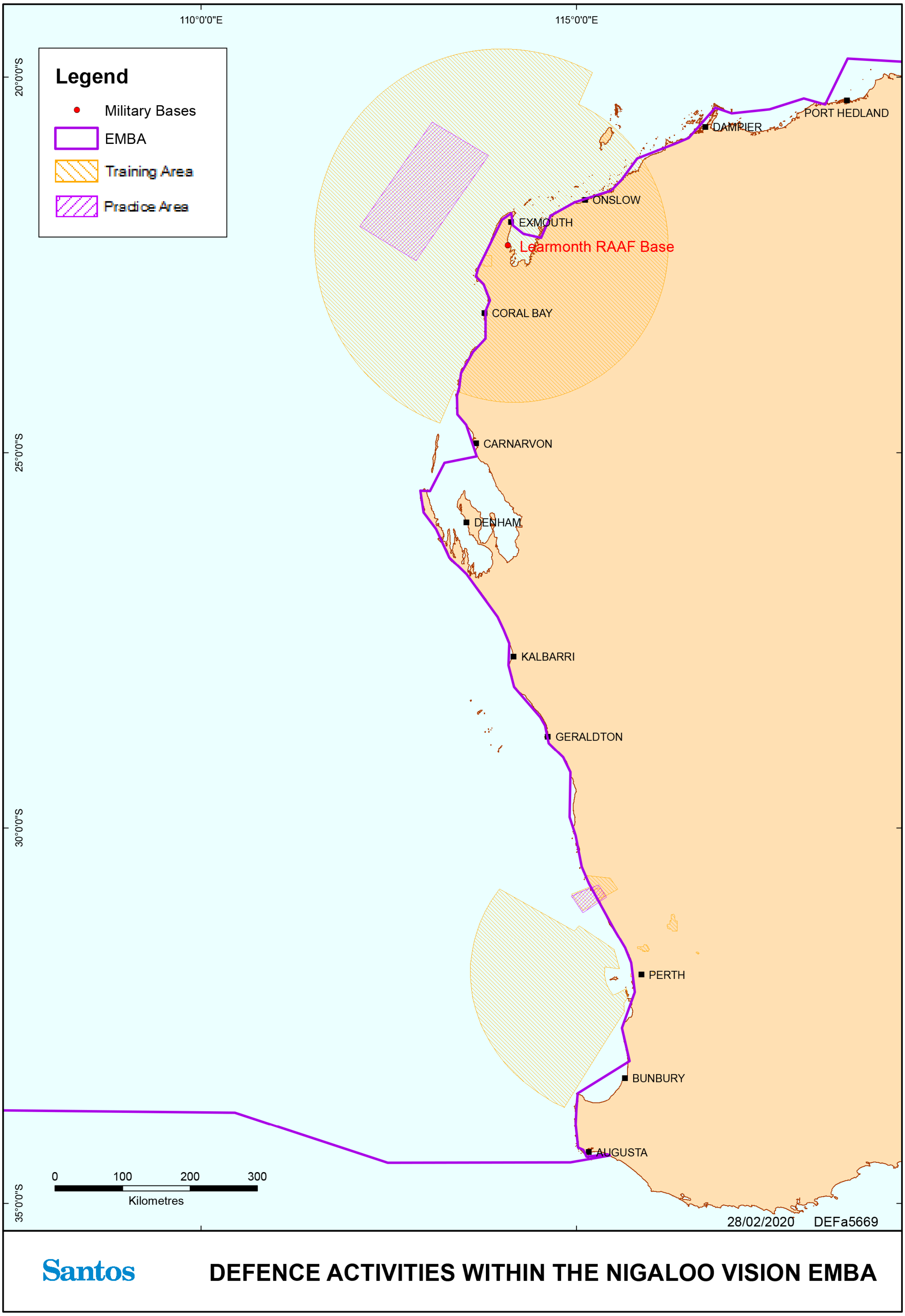

Figure 14-1: Defence activities in WA

14.4 Tourism

The Kimberley, Pilbara and Gascoyne regions are popular visitor destination for Australian and international tourists. Tourism is concentrated in the vicinity of population centres including Broome, Dampier, Exmouth, Coral Bay and Shark Bay.

Marine and coastal use is also clustered around major population centres along the WA coastline including Perth, Bunbury, Geraldton, Margaret River, Jurien Bay, August and Albany.

Tourism contributes to local economies in terms of both income and employment and tourists include local, interstate and international visitors. Popular water-based activities include fishing, swimming, snorkelling/ diving, surfing/windsurfing/kiting and boating, while popular land based activities include bushwalking, camping, bird watching and four-wheel driving.

Seasonal nature-based tourism such as humpback whale watching, whale shark encounters and tours of turtle hatching mainly occurring around Ningaloo Reef, Cape Range National Park, Broome and Perth (Tourism Western Australia 2014). Seasonal aggregations of whale sharks, manta rays, sea turtles and whales, as well as the annual mass spawning of coral attract large numbers of visitors to Ningaloo each year (CALM 2005).

The closest significant tourism to the operational area is located at Ningaloo Reef, 30 km from the operational area.

14.5 Cultural Heritage

Four places of cultural significance are protected as National Heritage Places in the waters from Busselton to the Northern Territory border. The Dampier Archipelago (including Burrup Peninsula), Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos, Dirk Hartog Landing Site 1616 – Cape Inscription area and the HMAS Sydney II and HSK Kormoran Shipwreck Site are discussed in **Section 9**.

14.5.1 Indigenous Heritage

Indigenous people have a strong ongoing association with the area that extends from the beginning of human settlement in Australia some 50,000 years ago. The close, long standing relationship between Aboriginal peoples and the coastal and marine environments of the area is evident in indigenous culture today in addition to archaeological sites such as the Burrup Peninsula. The Indigenous peoples of the northwest continue to rely on coastal and marine environments and resources for their cultural identity, health and wellbeing, as well as their domestic and commercial economies (DEWHA 2008). With the EMBA, Barrow Island, Montebello Islands, Exmouth, Ningaloo Reef, Eighty Mile Beach, Roebuck Bay, Dampier Peninsula and the South West and the adjacent foreshores have a long history of occupancy by Indigenous communities. Areas that are covered by registered native title claims are likely to practice indigenous fishing techniques at various sections of the WA coast line; most notably in the Kimberley coastal region and islands.

Marine resource use by Indigenous people is generally restricted to coastal waters. Fishing, hunting and the maintenance of maritime cultures and heritage through ritual, stories and traditional knowledge continue as important uses of the nearshore region and adjacent areas. However, while direct use by Aboriginal people deeper offshore waters is limited, many groups continue to have a direct cultural interest in decisions affecting the management of these waters. The cultural connections Aboriginal people maintain with the sea may be affected, for example, by offshore fisheries and industries. In addition, some Indigenous people are involved in commercial activities such as fishing and marine tourism, so have an interest in how these industries are managed in offshore waters with respect to their cultural heritage and commercial interests (DEWHA 2008).

14.5.2 Maritime Heritage

Details of recorded shipwreck sites are available on the Australian National Shipwreck Database are managed by the DoEE although precise locations of the wrecks are sometimes unknown. The Australian Heritage Database (AHD) was searched using the EMBA bounding coordinates. The AHD revealed the following shipwrecks within the EMBA which are protected under the *Underwater Cultural Heritage Act 2018* and could potentially be contacted by hydrocarbons in the event of an unplanned release during NV Operations:

- Fairy Queen – sailing vessel wrecked at North West Cape in 1875;
- Fin – single screw steamer wrecked at Fraser Island, Pt Cloates in 1923;
- Perth - twin steamer wrecked at Pt Cloates in 1887;
- Trial – sailing vessel wrecked at Trial rocks NW of the Montebello Islands in 1622;
- Zvir – twin steamer wrecked at Pt Cloates in 1902;
- Perentie- Barge wrecked at Barrow Island;
- Rowley Shoals unconfirmed wreck at Mermaid Reef in 1800
- Browse Island (East) unconfirmed wreck at Browse Island
- Gudrun- Iron frames at Cape Peron Flats in Shark Bay
- Zutydorp- Seventeenth century Dutch East Indiaman at Zutydorp cliffs 75km North of Kalbarri

14.6 Commercial and State Fisheries

Section 3.2.5.1 of the Ningaloo Vision Operations EP provides details of commercial and state fisheries within proximity to the operational area, PW mixing zone and EMBA.

14.7 Aquaculture

Aquaculture does not occur in the operational area given the water depth and distance from shore. Aquaculture in relation to the EMBA has been discussed in respect of the bioregions.

14.7.1 North Coast Bioregion

Aquaculture development in this region is dominated by the production of pearls from the species *Pinctada maxima.* A large number of pearl oysters for seeding is obtained from wild stocks and supplemented by hatchery-produced oysters with major hatcheries operating at Broome and the Dampier Peninsular. Pearl farm sites are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands. Developing marine aquaculture initiatives in this region include growing trochus and barramundi. Marine production of barramundi is focussed in Cone Bay fishing (Fletcher and Santoro 2015).

The Pearl Oyster Fishery of Western Australia operates in shallow coastal waters (DoF 2006). All the leases are within the 35m diving depth. Through consultation the Pearl Producer's Association (PPA) have raised concern that spawning stock is found to the 100 m depth contour. However, this is not supported in the study by Condie *et al* (2006) who modelled oyster larva transport in the Eighty Mile Beach region and found that while some larvae travelled more than 60 km, most were transported less than 30 km. The model results suggest that spawning in the Eighty Mile Beach region is concentrated around the 8 to 15m depth range, with potential smaller contributions from the northeast. These spawning events are likely to lead to successful recruitment locally and alongshore to the southwest.

They also feed larvae into neighbouring shallow coastal environments (through tidal oscillations) and deeper waters to the west (>20 m). However, spat abundances seem to be low in these areas, suggesting that recruitment is strongly limited by habitat availability and possibly high mortality rates in shallow water. High local abundances of broodstock and spat observed occasionally in deeper water (<30 m) seem to be supported by intermittent larval transport from inshore populations. Spawning in this area seems to contribute little to recruitment in the inshore populations.

Further aquaculture operations are expected in the region with recent funding supporting the establishment of an aquaculture zone (Gaughan *et al.* 2019).

14.7.2 Gascoyne Coast Bioregion

The Gascoyne Coast Bioregion extends from just north of Kalbarri to the Ashburton River, south of Onslow. The marine environment of this region represents a transition between the fully tropical waters of the north-west shelf of the north coast region and the temperate waters of the west coast region. This region has been identified as one of the 18 world ‘hotspots’ in terms of tropical reef endemism and the second most divers marine environment in the world in terms of tropical reef species. This region is a focal point for winter recreational fishing and is a key component of many tourist visits. Angling activities include beach and cliff fishing (e.g. Steep Point and Quobba), embayment and shallow-water boat angling (e.g. Shark Bay, Exmouth Gulf and Ningaloo lagoons), and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo). The predominant target species include the tropical species such as emperors, tropical snappers, groupers, mackerels, trevallies and other game fish. Temperate species at the northern end of their ranges such as pink snapper, tailor and whiting also provide significant catches, particularly in Shark Bay (WAFIC 2016).

14.7.3 West Coast Bioregion

The principal aquaculture development activities in this region are the production of blue mussels (*Mytilus galloprovincialis*) and marine algae (*Dunaliella salina*) and the emerging black pearl industry based on the production of *Pinctada margaritifera* at the Abrolhos Islands. The main mussel farming area is in southern Cockburn Sound, where conditions are sheltered and the nutrient and planktonic food levels are sufficient to promote good growth rates fishing (Fletcher and Santoro 2015).

Currently, the Department of Fisheries is seeking to secure strategic environmental approvals for a Mid-West Aquaculture Development Zone (Gaughan *et al*. 2019).

14.7.4 South West Bioregion

The predominant aquaculture activity undertaken in this region is the production of mussels and oysters from Oyster Harbour at Albany. This activity is restricted to this area where there are sufficient nutrient levels related to terrestrial run-off to provide the planktonic food necessary to promote growth of filter-feeding bivalves fishing (Fletcher and Santoro 2015). The high-energy environment and limited protected deep waters limits other forms of aquaculture.

14.7.5 Indonesian Aquaculture

An analysis by WorldFish has indicated that aquaculture will overtake capture fisheries as the major source of fish in Indonesia before 2030 (Phillips *et al.* 2015). By volume, Indonesian aquatic production is dominated by seaweeds, but by value, domestically consumed species such tilapia and milkfish, together with export-orientated commodities such as shrimp and tuna, are of greater importance (Phillips *et al*. 2015).

Carrageenan seaweed farming based primarily on the cultivation of *Kappaphycus* and *Eucheuma* species has grown significantly in Indonesia. Due to the simple farming techniques required, low requirements of capital and material inputs, and short production cycles it has become a favourable livelihood for smallholder farmers and fishers (Valderrama *et al*. 2013). Indonesia’s coastline provides ideal conditions for fish farming in “brackish waters”. Aquaculture in Indonesia is predominantly used for seaweed production, whilst offshore fish cultivation remains relatively undeveloped (Global Business Guide 2014).

14.8 Recreational Fisheries

Recreational fishing does not occur in the operational area given the water depth and distance from shore. Recreational in relation to the EMBA has been discussed in respect of the bioregions.

14.8.1 North Coast Bioregion

The North Coast Bioregion (Pilbara/Kimberley) runs from the Ashburton River to the Western Australia/Northern Territory border (WAFIC 2016). The oceanography of this region includes waters of Pacific Ocean origin that enter through the Indonesian archipelago bringing warm, low salinity waters poleward via the Indonesian throughflow and Holloway currents which flow seasonally and interact with Indian ocean waters.

Recreational fishing is experiencing a significant growth in this region, with a distinct seasonal peak in winter when the local population increases by significant numbers of metropolitan and inter-state tourists. This has been added to by the increased recreational fishing by those involved in the construction or operation of major developments in this region. Owing to the high tidal range, much of the angling activity is boat-based with beach fishing limited to periods of flood tides and high water. Numerous creek systems, mangroves, rivers and ocean beaches provide shore and small boat fishing for a variety of species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, mud crabs and cods. Offshore islands, coral reef systems and continental shelf waters provide species of major recreational interest including saddetail snapper and red emperor, cods, coral and coronation trout, sharks, trevally, tuskfish, mackerels and billfish (WAFIC 2016).

14.8.2 Gascoyne Coast Bioregion

The Gascoyne Coast Bioregion extends from just north of Kalbarri to the Ashburton River, south of Onslow. The marine environment of this region represents a transition between the fully tropical waters of the north-west shelf of the north coast region and the temperate waters of the west coast region. This region has been identified as one of the 18 world 'hotspots' in terms of tropical reef endemism and the second most divers marine environment in the world in terms of tropical reef species. This region is a focal point for winter recreational fishing and is a key component of many tourist visits. Angling activities include beach and cliff fishing (e.g. Steep Point and Quobba), embayment and shallow-water boat angling (e.g. Shark Bay, Exmouth Gulf and Ningaloo lagoons), and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo). The predominant target species include the tropical species such as emperors, tropical snappers, groupers, mackerels, trevallies and other game fish. Temperate species at the northern end of their ranges such as pink snapper, tailor and whiting also provide significant catches, particularly in Shark Bay (WAFIC 2016).

14.8.3 West Coast Bioregion

The marine environment of the West Coast Bioregion which lies between Kalbarri and Augusta is predominantly a temperate oceanic zone, but it is heavily influenced by the Leeuwin current, which transports warm tropical water southward along the edge of the continental shelf. This region contains the state's major population centres and is the most heavily used bioregion for recreational fishing (Fletcher and Santoro 2015). The range of recreational fishing opportunities includes estuarine fishing, beach fishing and boat fishing either in embayments or offshore for demersal and pelagic game species often around the islands and out to the continental shelf (WAFIC 2016).

14.8.4 Christmas Island Bioregion

The Christmas Island Province Bioregion can be found in the north western portion of the EMBA. Christmas Island's Territorial waters extend 12 nautical miles from the island's shore. The island has more than 50 reef fish species that are not found anywhere else in Australia (although some species may also occur at the neighbouring Cocos Islands). The island's waters also provide habitat for several EPBC listed and/or protected species including whale sharks, which generally visit the island's waters between November and April, dolphins and green and hawksbill turtles(Director of National Parks 2014)

Several companies conduct diving, boating or sportfishing tours within the park's and/or Territory's marine areas and many residents participate in recreational boating and fishing activities, which are important aspects of life for many island resident

The Territory's waters (to 12 nautical miles) are managed in accordance with any applied Western Australian Fisheries law

Santos

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Appendix D2 – EMBA PMST

Australian Government

Department of the Environment and Energy

EPBC Act Protected Matters Report

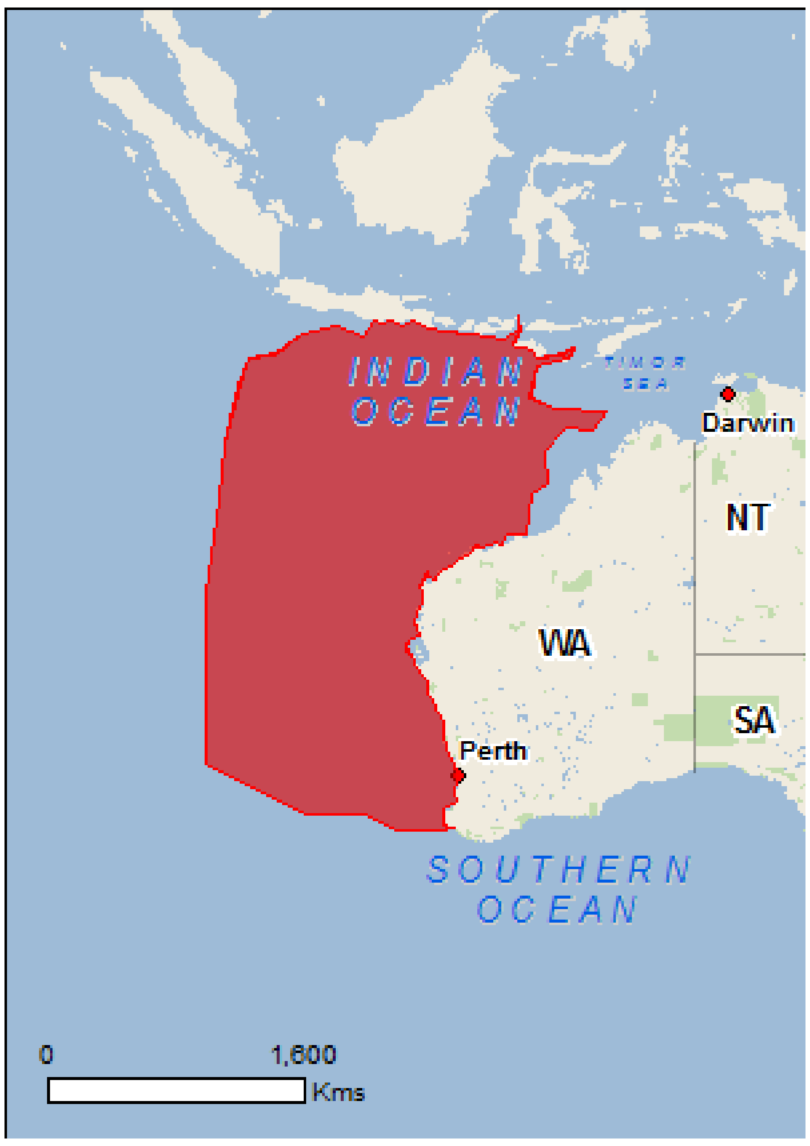
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

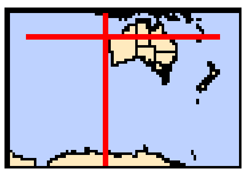
Report created: 04/02/20 18:09:48

- Summary
- Details
  - Matters of NES
  - Other Matters Protected by the EPBC Act
  - Extra Information
- Caveat
- Acknowledgements



Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	4
National Heritage Places:	7
Wetlands of International Importance:	5
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	6
Listed Threatened Species:	142
Listed Migratory Species:	101

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	15
Commonwealth Heritage Places:	23
Listed Marine Species:	199
Whales and Other Cetaceans:	43
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	1
Australian Marine Parks:	33

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	79
Regional Forest Agreements:	1
Invasive Species:	60
Nationally Important Wetlands:	12
Key Ecological Features (Marine)	19

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Australian Convict Sites (Fremantle Prison Buffer Zone)	WA	Buffer zone
Australian Convict Sites (Fremantle Prison)	WA	Declared property
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Shark Bay, Western Australia	WA	Listed place
The Ningaloo Coast	WA	Listed place
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place
Historic		
Batavia Shipwreck Site and Survivor Camps Area 1629 - Houtman Abrolhos	WA	Listed place
Dirk Hartog Landing Site 1616 - Cape Inscription Area	WA	Listed place
Fremantle Prison (former)	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Becher point wetlands	Within Ramsar site
Forrestdale and thomsons lakes	Within 10km of Ramsar
Hosnies spring	Within Ramsar site
Peel-yalgorup system	Within Ramsar site
The dales	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Aquatic Root Mat Community 1 in Caves of the Leeuwin Naturaliste Ridge	Endangered	Community known to occur within area
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community known to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to

Name	Status	Type of Presence
		occur within area
Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond)	Endangered	Community known to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area

Listed Threatened Species

[Resource Information]

Name	Status	Type of Presence
Birds		
Accipiter hiogaster natalis Christmas Island Goshawk [82408]	Endangered	Species or species habitat known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Breeding known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Chalcophaps indica natalis Christmas Island Emerald Dove, Emerald Dove (Christmas Island) [67030]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely

Name	Status	Type of Presence
		to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren [26004]	Vulnerable	Species or species habitat likely to occur within area
Ninox natalis Christmas Island Hawk-Owl, Christmas Boobook [66671]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur

Name	Status	Type of Presence
		within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Turdus poliocephalus erythropleurus Christmas Island Thrush [67122]	Endangered	Species or species habitat likely to occur within area
Turnix varius scintillans Painted Button-quail (Houtman Abrolhos) [82451]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Nannatherina balstoni Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Insects		
Hesperocolletes douglasi Douglas' Broad-headed Bee, Rottnest Bee [66734]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat known to occur within area
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Crocidura trichura Christmas Island Shrew [86568]	Critically Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus bernieri Rufous Hare-wallaby (Bernier Island) [66662]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus dorreae Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur within area
Lagostrophus fasciatus fasciatus Banded Hare-wallaby, Merrnine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Breeding known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Parantechinus apicalis Dibbler [313]	Endangered	Species or species habitat known to occur within area
Perameles bougainville bougainville Western Barred Bandicoot (Shark Bay) [66631]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Pipistrellus murrayi Christmas Island Pipistrelle [64383]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat known to occur within area
Pseudomys fieldi Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Pteropus natalis Christmas Island Flying-fox, Christmas Island Fruit-bat [87611]	Critically Endangered	Roosting known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat known to occur within area
Other		
Idiosoma nigrum Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat known to occur within area
Kumonga exleyi Cape Range Remipede [86875]	Vulnerable	Species or species habitat known to occur within area
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Androcalva bivillosa Straggling Androcalva [87807]	Critically Endangered	Species or species habitat may occur within area
Asplenium listeri Christmas Island Spleenwort [65865]	Critically Endangered	Species or species habitat known to occur within area
Banksia nivea subsp. uliginosa Swamp Honeypot [82766]	Endangered	Species or species habitat may occur within area
Beyeria lepidopetala Small-petalled Beyeria, Short-petalled Beyeria [18362]	Endangered	Species or species habitat likely to occur within area
Caladenia barbarella Small Dragon Orchid, Common Dragon Orchid [68686]	Endangered	Species or species habitat may occur within area
Caladenia bryceana subsp. cracens Northern Dwarf Spider-orchid [64556]	Vulnerable	Species or species habitat may occur within area
Caladenia caesarea subsp. maritima Cape Spider-orchid [64856]	Endangered	Species or species habitat may occur within area
Caladenia elegans Elegant Spider-orchid [56775]	Endangered	Species or species habitat likely to occur within area
Caladenia excelsa Giant Spider-orchid [56717]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Caladenia hoffmanii Hoffman's Spider-orchid [56719]	Endangered	Species or species habitat likely to occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Caladenia lodgeana Lodge's Spider-orchid [68664]	Critically Endangered	Species or species habitat known to occur within area
Caladenia viridescens Dunsborough Spider-orchid [56776]	Endangered	Species or species habitat likely to occur within area
Calectasia cyanea Blue Tinsel Lily [7669]	Critically Endangered	Species or species habitat may occur within area
Chamelaucium sp. Gingin (N.G.Marchant 6) Gingin Wax [88881]	Endangered	Species or species habitat likely to occur within area
Chorizema varium Limestone Pea [16981]	Endangered	Species or species habitat known to occur within area
Diuris drummondii Tall Donkey Orchid [4365]	Vulnerable	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Drummondita ericoides Morseby Range Drummondita [9193]	Endangered	Species or species habitat likely to occur within area
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus cuprea Mallee Box [56773]	Endangered	Species or species habitat may occur within area
Eucalyptus x phylacis Meelup Mallee [87817]	Endangered	Species or species habitat known to occur within area
Gastrolobium papilio Butterfly-leaved Gastrolobium [78415]	Endangered	Species or species habitat may occur within area
Hemiandra gardneri Red Snakebush [7945]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Kennedia lateritia Augusta Kennedia [45985]	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Marianthus paralius [83925]	Endangered	Species or species habitat known to occur within area
Pityrodia augustensis Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Pneumatopteris truncata fern [68812]	Critically Endangered	Species or species habitat known to occur within area
Sphenotoma drummondii Mountain Paper-heath [21160]	Endangered	Species or species habitat likely to occur within area
Tectaria devexa [14767]	Endangered	Species or species habitat likely to occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area
Wurmbea calcicola Naturaliste Nancy [64691]	Endangered	Species or species habitat known to occur within area
Wurmbea tubulosa Long-flowered Nancy [12739]	Endangered	Species or species habitat may occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus egeriae Christmas Island Blue-tailed Skink, Blue-tailed Snake-eyed Skink [1526]	Critically Endangered	Species or species habitat likely to occur within area
Ctenotus lancelini Lancelin Island Skink [1482]	Vulnerable	Species or species habitat known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Cyrtodactylus sadleiri Christmas Island Giant Gecko [86865]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-	Endangered	Species or species

Name	Status	Type of Presence
tailed Skink [64483]		habitat likely to occur within area
Emoia nativitatis Christmas Island Forest Skink, Christmas Island Whiptail-skink [1400]	Critically Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Lepidodactylus listeri Christmas Island Gecko, Lister's Gecko [1711]	Critically Endangered	Species or species habitat known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Liopholis pulchra longicauda Jurien Bay Skink, Jurien Bay Rock-skink [83162]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Ramphotyphlops exocoeti Christmas Island Blind Snake, Christmas Island Pink Blind Snake [1262]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Breeding known to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Congregation or aggregation known to occur within area

Name	Threatened	Type of Presence
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Breeding known to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or

Name	Threatened	Type of Presence
		related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or related behaviour known to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta		
Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus		
Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Gallinago megala		
Swinhoe's Snipe [864]		Roosting likely to occur

Name	Threatened	Type of Presence
		within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Christmas Island National Park
Defence - ARTILLERY BARRACKS - FREMANTLE
Defence - CAMPBELL BARRACKS - SWANBOURNE
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - GERALDTON TRAINING DEPOT "A" Company 16th Battalion
Defence - GREENOUGH RIFLE RANGE
Defence - HMAS STIRLING-ROCKINGHAM ;HMAS STIRLING - GARDEN ISLAND
Defence - LANCELIN TRAINING AREA
Defence - LEARMONTH - AIR WEAPONS RANGE
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - LEEUWIN BARRACKS - EAST FREMANTLE
Defence - ROCKINGHAM - NAVY CPSO
Defence - SWANBOURNE RIFLE RANGE

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Christmas Island Natural Areas	EXT	Listed place
Garden Island	WA	Listed place
Lancelin Defence Training Area	WA	Listed place
Learmonth Air Weapons Range Facility	WA	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Historic		
Administrators House Precinct	EXT	Listed place
Artillery Barracks	WA	Listed place
Bungalow 702	EXT	Listed place
Cape Leeuwin Lighthouse	WA	Listed place
Cliff Point Historic Site	WA	Listed place
Drumsite Industrial Area	EXT	Listed place
Geraldton Drill Hall Complex	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Industrial and Administrative Group	EXT	Listed place
J Gun Battery	WA	Listed place
Malay Kampong Group	EXT	Listed place
Malay Kampong Precinct	EXT	Listed place
Phosphate Hill Historic Area	EXT	Listed place
Poon Saan Group	EXT	Listed place
Settlement Christmas Island	EXT	Listed place
South Point Settlement Remains	EXT	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding likely to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area

Name	Threatened	Type of Presence
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Puffinus assimilis Little Shearwater [59363]		Breeding known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Breeding known to occur within area
Puffinus huttoni Hutton's Shearwater [1025]		Foraging, feeding or related behaviour known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna albifrons Little Tern [813]		Congregation or aggregation known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely

Name	Threatened	Type of Presence
		to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys sculptus Sculptured Pipefish [66197]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Cosmocampus maxweberi Maxweber's Pipefish [66209]		Species or species habitat may occur within area
Doryrhamphus baldwini Redstripe Pipefish [66718]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus macrorhynchus Whiskered Pipefish, Ornate Pipefish [66222]		Species or species habitat may occur within area
Halicampus mataafae Samoan Pipefish [66223]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippichthys spicifer Belly-barred Pipefish, Banded Freshwater Pipefish [66232]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat likely to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Hyperoodon planifrons Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or related behaviour known to occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area

Name	Status	Type of Presence
[Stenella coeruleoalba] Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
[Stenella longirostris] Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
[Steno bredanensis] Rough-toothed Dolphin [30]		Species or species habitat may occur within area
[Tasmacetus shepherdi] Shepherd's Beaked Whale, Tasman Beaked Whale [55]		Species or species habitat may occur within area
[Tursiops aduncus] Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
[Tursiops aduncus (Arafura/Timor Sea populations)] Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
[Tursiops truncatus s. str.] Bottlenose Dolphin [68417]		Species or species habitat may occur within area
[Ziphius cavirostris] Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Christmas Island	EXT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Carnarvon Canyon	Habitat Protection Zone (IUCN IV)
Dampier	Habitat Protection Zone (IUCN IV)
Dampier	Multiple Use Zone (IUCN VI)
Dampier	National Park Zone (IUCN II)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Geographe	Multiple Use Zone (IUCN VI)
Geographe	Special Purpose Zone (Mining
Jurien	National Park Zone (IUCN II)
Jurien	Special Purpose Zone (IUCN VI)
Kimberley	Multiple Use Zone (IUCN VI)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Perth Canyon	Habitat Protection Zone (IUCN IV)
Perth Canyon	Multiple Use Zone (IUCN VI)
Perth Canyon	National Park Zone (IUCN II)
Shark Bay	Multiple Use Zone (IUCN VI)

Name	Label
South-west Corner	Multiple Use Zone (IUCN VI)
South-west Corner	National Park Zone (IUCN II)
South-west Corner	Special Purpose Zone (Mining
Two Rocks	Multiple Use Zone (IUCN VI)
Two Rocks	National Park Zone (IUCN II)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Airlie Island	WA
Barrow Island	WA
Bedout Island	WA
Beekeepers	WA
Bernier And Dorre Islands	WA
Bessieres Island	WA
Bold Park	WA
Boodie, Double Middle Islands	WA
Boullanger, Whitlock, Favourite, Tern And Osprey Islands	WA
Bundegi Coastal Park	WA
Burnside And Simpson Island	WA
Cape Range	WA
Carnac Island	WA
Dirk Hartog Island	WA
Dongara	WA
Escape Island	WA
Flinders Bay	WA
Gnandaroo Island	WA
Hamelin Island	WA
Jurabi Coastal Park	WA
Kalbarri	WA
Koks Island	WA
Lancelin And Edwards Islands	WA
Leeuwin-Naturaliste	WA
Little Rocky Island	WA
Locker Island	WA
Lowendal Islands	WA
Montebello Islands	WA
Muiron Islands	WA
Nambung	WA
Nilgen	WA
North Sandy Island	WA
Part Murchison house	WA
Penguin Island	WA
Port Kennedy Scientific Park	WA
Rottnest Island	WA
Round Island	WA
Seal Island (WA25645)	WA
Serrurier Island	WA
Southern Beekeepers	WA
St Alouarn Island	WA
Sugar Loaf Rock	WA
Swan River	WA
Tamala Pastoral Lease (Part)	WA
Tent Island	WA
Unnamed WA26400	WA
Unnamed WA33799	WA

Name	State
Unnamed WA36907	WA
Unnamed WA36909	WA
Unnamed WA36910	WA
Unnamed WA36913	WA
Unnamed WA36915	WA
Unnamed WA37338	WA
Unnamed WA37383	WA
Unnamed WA37500	WA
Unnamed WA39584	WA
Unnamed WA39752	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA40877	WA
Unnamed WA41080	WA
Unnamed WA42469	WA
Unnamed WA43903	WA
Unnamed WA44665	WA
Unnamed WA44667	WA
Unnamed WA44672	WA
Unnamed WA44682	WA
Unnamed WA44688	WA
Unnamed WA48858	WA
Unnamed WA48968	WA
Unnamed WA49220	WA
Unnamed WA49994	WA
Victor Island	WA
Wanagarren	WA
Wedge Island	WA
Weld Island	WA
Y Island	WA
Yalgorup	WA
Zuytdorp	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Gallus gallus Red Junglefowl, Domestic Fowl [917]		Species or species habitat likely to occur within area
Lonchura oryzivora Java Sparrow [59586]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pavo cristatus Indian Peafowl, Peacock [919]		Species or species habitat likely to occur within area
Phasianus colchicus Common Pheasant [920]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel		Species or species

Name	Status	Type of Presence
[129]		habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom,		Species or species

Name	Status	Type of Presence
Common Broom, French Broom, Soft Broom [20126]		habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea		
Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata		
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla		
Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lycodon aulicus		
Wolf Snake, Common Wolf Snake, Asian Wolf Snake [83178]		Species or species habitat likely to occur within area
Lygosoma bowringii		
Christmas Island Grass-skink [1312]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
"The Dales", Christmas Island	EXT
Cape Leeuwin System	WA
Cape Range Subterranean Waterways	WA
Exmouth Gulf East	WA
Hosine's Spring, Christmas Island	EXT
Lake Thetis	WA
Learmonth Air Weapons Range - Saline Coastal Flats	WA
Mermaid Reef	EXT
Rottnest Island Lakes	WA
Shark Bay East	WA
Swan-Canning Estuary	WA
Yalgorup Lakes System	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Seringapatam Reef and Commonwealth waters in	North-west
Wallaby Saddle	North-west
Ancient coastline at 90-120m depth	South-west
Cape Mentelle upwelling	South-west
Commonwealth marine environment surrounding	South-west
Commonwealth marine environment within and	South-west
Commonwealth marine environment within and	South-west
Naturaliste Plateau	South-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west
Western rock lobster	South-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-9.055581 116.524383,-9.240479 118.474258,-8.774104 119.188097,-8.150686 119.150025,-8.716997 119.3499,-9.579062 118.903844,-9.72113 119.045329,-9.725889 119.292793,-9.754442 119.564051,-9.949558 119.887658,-10.33979 120.249336,-10.106603 121.719843,-9.80679 122.328985,-10.330272 121.95303,-10.768093 120.135122,-12.452751 119.821033,-13.066652 121.234433,-13.304598 124.070751,-14.199275 123.309323,-14.08982 121.891164,-15.365211 120.682398,-17.136522 120.77024,-17.634536 119.93635,-19.813527 119.640107,-19.751066 118.61218,-20.361947 118.311072,-20.28466 118.026833,-20.426929 117.571694,-20.47843 117.066746,-20.407797 116.847215,-20.805762 116.49565,-20.870543 116.343437,-21.078354 115.810359,-21.364341 115.601567,-21.51547 115.455254,-21.672092 114.975132,-21.844663 114.654778,-22.14064 114.527241,-22.088887 114.293459,-21.974672 114.15426,-21.812274 114.13463,-21.901504 114.009708,-22.545743 113.695619,-22.654603 113.661712,-22.756325 113.765218,-22.972261 113.849094,-23.118598 113.790203,-23.479087 113.790203,-23.655762 113.622451,-23.943082 113.463622,-24.12868 113.438637,-24.248247 113.408299,-24.492975 113.412642,-24.630746 113.531139,-25.051143 113.67371,-25.136804 113.245407,-25.513353 113.050886,-25.50443 112.92418,-25.797104 112.96701,-26.014726 113.131759,-26.39541 113.306164,-26.621452 113.538996,-27.186354 113.948722,-27.357675 114.028434,-27.543273 114.106956,-27.833567 114.096248,-28.119103 114.170012,-28.520042 114.517413,-28.635446 114.580469,-28.869681 114.630704,-29.058481 114.823171,-29.255628 114.920029,-29.854963 114.911659,-30.103041 114.989604,-30.513555 115.069355,-30.740087 115.167444,-31.371218 115.513475,-31.598362 115.649183,-31.794481 115.731026,-32.184737 115.776314,-32.663746 115.605248,-33.105156 115.706592,-33.532082 115.01457,-33.728682 114.999254,-33.942459 114.990576,-34.254188 115.019475,-34.288925 115.091266,-34.375768 115.132507,-34.344536 115.41349,-34.361358 115.446426,-34.452038 114.920732,-34.4565 112.488328,-33.79025 110.453888,-33.758921 107.288412,-31.39872 101.747931,-28.30542 101.771725,-22.904772 101.720473,-17.97856 102.485564,-15.028028 102.771099,-11.83955 103.580116,-10.277924 104.054725,-10.106603 105.539508,-9.069158 107.133747,-8.578989 108.97545,-9.140541 110.450716,-8.283935 111.136001,-8.455257 111.616652,-8.298212 111.973571,-8.502846 112.677891,-8.283935 113.191855,-8.721756 114.291166,-8.855006 115.057352,-9.055581 116.524383

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- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix D3 – Operational Area PMST

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

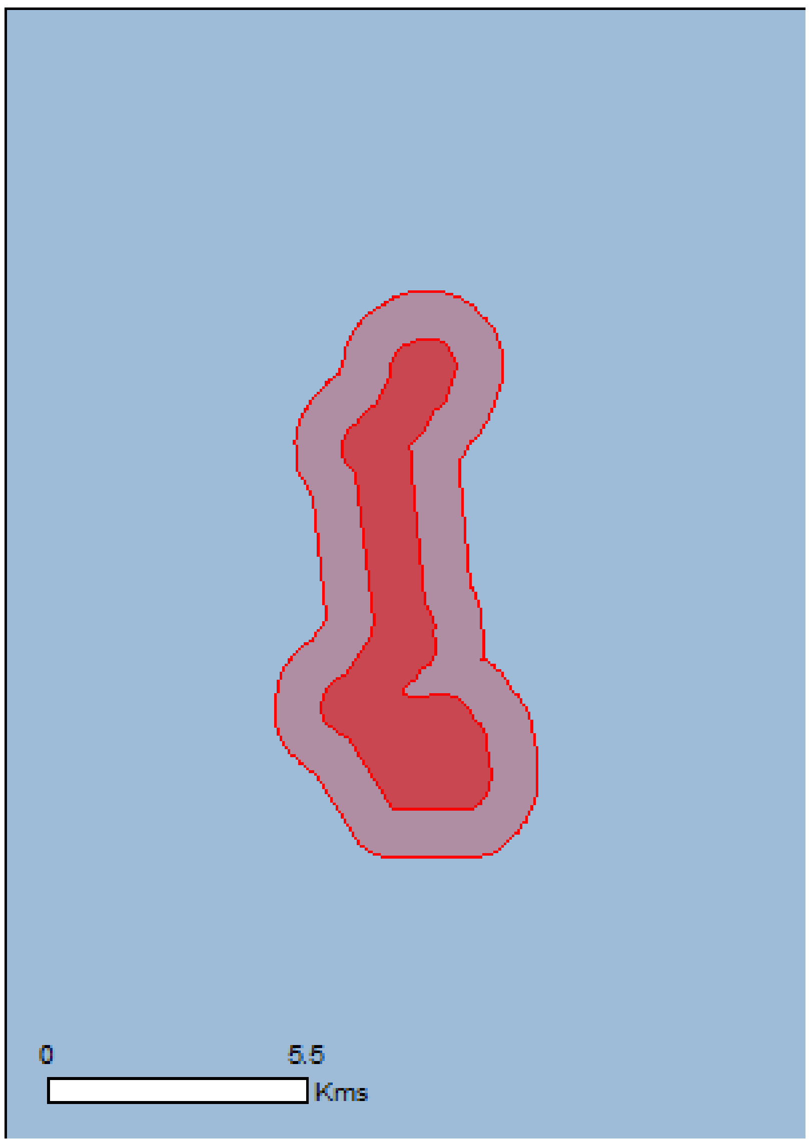
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

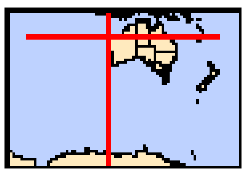
Report created: 13/05/19 15:27:55

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	16
Listed Migratory Species:	30

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	27
Whales and Other Cetaceans:	24
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area

Name	Threatened	Type of Presence
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Continental Slope Demersal Fish Communities	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-21.3915707509389 114.066162989295,-21.384529507568 114.070963837048,-21.3834778932983 114.071066712357,-21.3821062225117 114.071501074773,-21.3557244210504 114.068197634295,-21.354947140938 114.066963130587,-21.352798190039 114.06568290452,-21.3503177520334 114.065511445672,-21.3479973422861 114.06668879643,-21.3466371020894 114.068369093143,-21.3457398007832 114.068986344997,-21.345351160727 114.069409276823,-21.3448139230023 114.070129403986,-21.3445853112046 114.070552335812,-21.3440137817102 114.071306754745,-21.3436022804742 114.072038312498,-21.3383327785359 114.074427305784,-21.3376240819628 114.074404444604,-21.3366181900527 114.074570188158,-21.3356923122717 114.07488452938,-21.3347950109655 114.075376044745,-21.3338519872998 114.076301922526,-21.3332233048559 114.077342106205,-21.3327832271453 114.078342282821,-21.3319545093784 114.079822544211,-21.3320116623278 114.083411749436,-21.3326746365413 114.084703406093,-21.3335662225526 114.085675006234,-21.3344921003335 114.086429425166,-21.3353836863448 114.086829495812,-21.3361381052774 114.087023815841,-21.3371782889572 114.08704667702,-21.3382756255864 114.086829495812,-21.3398187552213 114.08601792393,-21.3412475789573 114.085777881543,-21.3427335556427 114.08509204615,-21.3441395181989 114.083651791824,-21.3447110476933 114.082497302245,-21.3481630858395 114.08095417261,-21.3497176460642 114.079879697161,-21.3511921921598 114.078336567526,-21.352415265278 114.078725207582,-21.3532725595194 114.078816652301,-21.354129853761 114.078759499352,-21.3553986492386 114.078428012245,-21.3789913867673 114.081274229127,-21.3804316410932 114.082394426936,-21.3816204224415 114.082851650531,-21.382489147273 114.08298881761,-21.384020846318 114.082943095251,-21.3852324888461 114.083331735307,-21.3865812984529 114.083377457666,-21.3879758304192 114.083057401149,-21.3897132800822 114.0819829257,-21.3907877555316 114.080382643116,-21.3920679815991 114.079628224183,-21.3931195958688 114.078370859295,-21.3934082182634 114.077550714471,-21.3941340607213 114.077299241493,-21.3948027502298 114.076967754387,-21.3952885503 114.078528029906,-21.3951971055809 114.085912190974,-21.3955278782758 114.08688593435,-21.3956793335918 114.087266001464,-21.3959879595188 114.087846103901,-21.3962994430932 114.088289039259,-21.3968538267028 114.088934867587,-21.3977625585989 114.08968928652,-21.3987455893292 114.090272246604,-21.399482862377 114.090580872531,-21.4003115801439 114.091655347981,-21.4010031308321 114.09223259277,-21.4018575674262 114.092658382243,-21.4023376522015 114.092824125797,-21.4032806758673 114.09297843876,-21.4068355893224 114.093435662356,-21.4088759496174 114.093721427103,-21.4102590509939 114.093698565923,-21.4109677475669 114.093601405909,-21.4118421876933 114.093327071752,-21.4127737807692 114.092835556387,-21.413613929126 114.092212589238,-21.4141968892103 114.091618198564,-21.4147055504603 114.09097808553,-21.4154278208588 114.090232953952,-21.415410674974 114.075038842343,-21.4024883931057 114.066605924653,-21.4018482800719 114.064697016142,-21.4012081670382 114.063656832462,-21.4002194210129 114.062633794667,-21.3991392302685 114.061942243979,-21.3980304630494 114.061599326282,-21.3969216958302 114.061525027448,-21.3952642602965 114.06183936867,-21.3940640483583 114.062496627589,-21.3932810529509 114.063211039457,-21.3925723563779 114.064102625468,-21.3915707509389 114.066162989295

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
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-Australian Government, Department of Defence
Forestry Corporation, NSW
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-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix E. Stakeholder Engagement

Santos

Ningaloo Vision Operations

Environment Plan Revision

STAKEHOLDER CONSULTATION

STAKEHOLDER CONSULTATION

Consultation Correspondence

Example of communication with stakeholders

From: Consultation, [redacted]

[redacted]

Subject: Santos Consultation | Ningaloo Vision Operations EP Revision

Date: Thursday, 13 February 2020 1:41:00 PM

Attachments: image001.jpg
Santos Ningaloo Vision Operations EP Revision Consultation Package -February 2020.pdf
image006.jpg
image011.jpg
image013.jpg
image014.jpg
image015.jpg
image016.jpg

Good afternoon

Please be advised that Santos is preparing to submit its five-yearly regulatory revision of the *Ningaloo Vision* Operations Environment Plan.

Santos previously emailed you a copy of the Consultation Package for this revision on 27 May 2019, and no comments were received at the time.

An updated Consultation Pack is now attached for your information should you wish to raise any matters with us.

Kind regards

[redacted]

Santos Limited, Level 7 100 St Georges Tce, Perth WA 6000

[redacted] [redacted]

https://www.santos.com/

From: Consultation, [redacted]

Sent: Monday, 27 May 2019 8:45 AM

Subject: Santos Consultation | Ningaloo Vision Operations EP Revision

Dear stakeholders,

Please be advised Santos Limited (Santos) is preparing to revise the Ningaloo Vision Operations Environment Plan (EP), relating to the operations of the *Ningaloo Vision* FPSO approximately 57 km from Exmouth, in Commonwealth Waters.

As outlined in attached consultation material, Santos is required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009) to revise operations EP's every five years. Primarily, the EP will be remaining consistent with the previous revision accepted by NOPSEMA in 2015.

Please be aware recent amendments to the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (the Environment Regulations) require NOPSEMA to publish a copy of a proponent's EP upon submission and again upon acceptance.

As a relevant stakeholder you are invited to provide comments on this EP. All correspondence relating to the Ningaloo Vision Operations EP will be contained in the consultation report that is provided to NOPSEMA by Santos, as required by the Environment Regulations. Santos will not use or disclose your personal information in this report.

If you do not wish for your comments to be published in this EP, or wish to provide your comments anonymously, you should make this known to Santos when you respond to this document.

If you wish to receive more information from Santos on this, or any activity, please be in contact on the details below. Any comments on this activity would be appreciated by 31 July 2019.

Kind regards

[redacted]

Santos Limited, Level 7 100 St Georges Tce, Perth WA 6000

t: [redacted] [redacted]

https://www.santos.com/

From: Consultation, [redacted]
To: [redacted]
Cc: [redacted]
Subject: RE: Santos Limited | Quarterly Consultation Update
Date: Thursday, 13 February 2020 1:33:00 PM
Attachments: image004.jpg
image013.png
image015.jpg
image016.jpg
image017.jpg
Santos Ningaloo Vision Operations EP Revision Consultation Package -February 2020.pdf
image001.jpg
image002.jpg
image003.jpg
image005.png

Good afternoon

Please be advised that Santos is preparing to submit its five-yearly regulatory revision of the *Ningaloo Vision* Operations Environment Plan (EP).

Santos previously emailed [redacted] a copy of the Consultation Package for this revision on 27 May 2019, and you kindly responded on 27 June 2019 as per the below email.

An updated Consultation Pack is now attached for your information should you wish to raise any further matters with us.

Kind regards

[redacted]
Santos Limited, Level 7 100 St Georges Tce, Perth WA 6000
[redacted] [redacted]
https://www.santos.com/

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

Example of Communication to Exmouth Community Stakeholders

From: [redacted]
Bcc: [redacted]
Subject: Santos Consultation | Ningaloo Vision Operations EP Revision
Date: Wednesday, 6 March 2019 4:52:00 PM
Attachments: Santos Ningaloo Vision Operations EP Revision Consultation Package.pdf
image001.jpg
image002.jpg
image003.jpg
image004.jpg

Dear stakeholders,

Please be advised Santos Limited (Santos) is preparing to revise the Ningaloo Vision Operations Environment Plan (EP), relating to the operations of the *Ningaloo Vision* FPSO approximately 57 km from Exmouth, in Commonwealth Waters.

As outlined in attached consultation material, Santos is required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009) to revise operations EP's every five years. Primarily, the EP will be remaining consistent with the previous revision accepted by NOPSEMA in 2015.

If you wish to receive more information from Santos on this, or any activity, please be in contact on the details below.

Kind regards

[redacted]

[redacted]
Santos Limited, Level 7 100 St Georges Tce, 6000
[redacted]
santos.com

From:	Consultation, [redacted]
[redacted]	[redacted]
Subject:	Santos Consultation | Ningaloo Vision Operations EP Revision
Date:	Tuesday, 3 March 2020 5:25:00 PM
Attachments:	Santos Ningaloo Vision Operations EP Revision Consultation Package -February 2020.pdf image001.jpg image008.jpg image009.jpg image010.jpg

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Good afternoon

Santos is the operator of the Ningaloo Vision Floating Production Storage and Offloading (FPSO) vessel located approximately 40 km offshore from the Town of Exmouth. Production from the facility commenced in 2010 in accordance with Commonwealth government regulatory environmental approvals.

In accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009, Santos is planning to submit its five-yearly revision of the *Ningaloo Vision* Operations Environment Plan to NOPSEMA in April 2020.

Santos previously emailed you a copy of the Consultation Package for this revision on 6 March 2019, and has provided regular updates on the EP at the Exmouth Community Reference Group Meetings. Stakeholder comments received have been incorporated into the revised EP.

An updated Consultation Pack is now attached for your information. Within the attached, please note:

- changes to the provision of contingent overboard discharge of produced water; and
- the FPSO is due to disconnect and sail away in Q2 of 2020, to undergo a planned dry dock and maintenance program, returning to site in Q3/Q4 2020.

Santos will be provide a brief on the EP at the next meeting of the Exmouth Community Reference Group scheduled for Thursday 12 March 2020. However if you are unable to attend that meeting, or would prefer a separate briefing, we will be happy to accommodate that.

Should you require additional information or have additional comments to make about the ongoing operation, please be in touch via the contact details below. Alternatively, please let me know if you would like to schedule to meeting in Exmouth on or around the 12 March.

Kind regards

[redacted]
Santos Limited, Level 7 100 St Georges Tce, Perth WA 6000
t: [redacted]

https://www.santos.com/

Example of communication to Commercial Fishers

From: [redacted]
To: [redacted]
Cc: [redacted]
Subject: ![EXT]: 2020 Feb 13 - [redacted] Santos Ningaloo Vision - 5 year review - 57km north of Exmouth
Date: Thursday, 13 February 2020 2:03:08 PM
Attachments: image001.jpg
image002.jpg
image003.jpg
Santos Ningaloo Vision Operations EP Revision Consultation Package -February 2020.pdf
ACa5036_Ningaloo_Vision_Loc_Map_Op_Area.pdf

Good afternoon Licence Holders

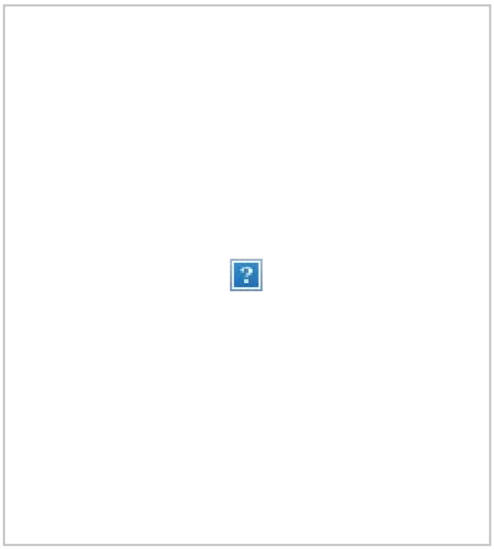
Santos is preparing to submit its five-yearly revision of the Ningaloo Vision Operations Environment Plan (EP). All EPs must go through a five year review, required under the regs - Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

WAFIC is sending this information to commercial fishers on a fee-for-service basis on behalf of Santos to ensure all licence holders receive this in a timely manner via an accurate list. All feedback / input etc is to go directly to [redacted] Santos (see below).

Please note, this is an ongoing activity which has operated offshore from Exmouth since 2009/2010, it is “business as usual”. Some licence holders may have received Ningaloo Vision information from Santos last year, however Santos is keen to ensure all relevant commercial fishers are provided the opportunity for input.

On behalf of Santos, please find attached a detailed fact sheet and a larger map, summary information relevant to commercial fishers is noted below:

Ningaloo Vision Operations:



Location: In permit number WA-35-L (Commonwealth waters) approximately 57 km North of the Exmouth Township and 45 km from Cape Range Peninsula - Latitude 21°24'12.39" E, Longitude 114°05'17.22" N.

Water Depth: Ranges from 340 m in the east of production licence WA-35-L, to 400 m depth in the west.

Production: Ongoing operations.
The *Ningaloo Vision* FPSO (Floating, Production, Storage and Offloading unit) is due to disconnect and sail away in Q2 of 2020, to undergo a planned dry dock and maintenance program returning to site in Q3/Q4 2020.

Exclusion Zone: A pre-existing 500 metre exclusion zone around the FPSO and Detachable Turret Mooring (DTM) and 2.5 nm cautionary zone at all times.
Commercial fishers can anchor, fish and or transit the cautionary zone as long as it is safe to do so. There are no new exclusion zones.

Support Vessels: The support vessel is the *Mermaid Cove*. Additional support is provided on an as needs basis by smaller jet-propelled utility vessels. The *Mermaid Cove* operates out of Dampier.

Environmental Management:
An overview of measures in place to manage or mitigate the associated impacts and risks is attached. Please note changes to the provision of contingent overboard discharge of produced water.

If you have any issues or concerns with the Ningaloo Vision activities and/or any other issues relevant to this location and this proposed ongoing activity then please respond directly to Santos: [redacted]

Santos has noted that you please be aware that your feedback will be communicated via the EP to NOPSEMA, as is required under legislation.

Look forward to your feedback.

Many thanks and best regards

[redacted]
WAFIC - Fishing, Pearling, Aquaculture

[redacted]

L1, 56 Marine Tce. Fremantle WA 6160
PO Box 1605. Fremantle WA 6959

[redacted]

wafic.org.au
wamsc.com.au

STAKEHOLDER CONSULTATION

Consultation Pack

Ningaloo Vision Operations Environment Plan Revision

Santos Limited (Santos) is the operator of the *Ningaloo Vision* Floating, Production, Storage Offtake (FPSO) facility. The *Ningaloo Vision* FPSO stores and produces oil from the Van Gogh, Coniston and Novara fields in Commonwealth waters, approximately 57 km North of the Exmouth Township. Operations occur in water depths ranging from 340 m in the east of production licence WA-35-L, to 400 m depth in the west.

Background

Petroleum activities in Commonwealth waters are regulated by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), a Commonwealth statutory authority.

Before Santos can undertake a petroleum activity (including operating a facility), our plan for managing the environment (the Environment Plan) must be accepted by NOPSEMA in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009). The current revision of the *Ningaloo Vision Operations Environment Plan* was accepted by NOPSEMA in 2015.

This consultation package relates to the five-yearly revision of the *Ningaloo Vision Operations Environment Plan,* required in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009).

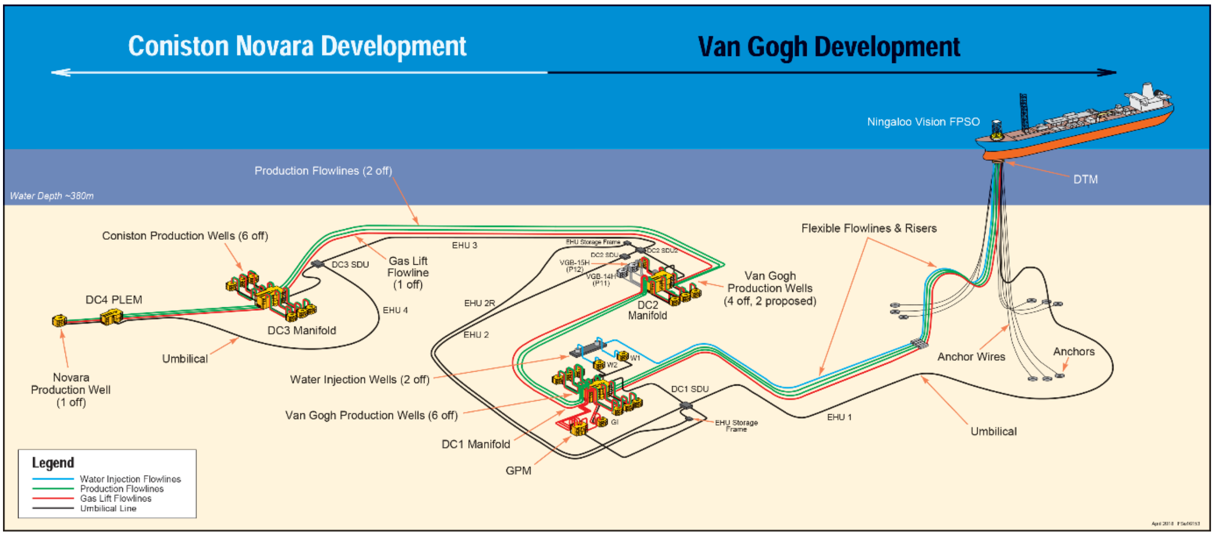
Activity overview

The Van Gogh, Coniston and Novara field subsea production system includes oil production, gas injection and water reinjection wells, and subsea manifolds connected to the FPSO via flexible flowlines and risers. Oil has been recovered from the Van Gogh field using the *Ningaloo Vision* FPSO since 2009/10, and comingled with oil from the Coniston and Novara fields since 2015.

The Environment Plan Operational Area (see map on page 5) is defined as the area within the 500 m Petroleum Exclusion Zone that extends around the *Ningaloo Vision* FPSO (whilst at mooring), the Detachable Turret Mooring, anchor spread and all other subsea infrastructure of the Coniston, Novara and Van Gogh Developments.

The estimated operational life of the Van Gogh, Coniston and Novara fields is 15 to 20 years.

Facility	Water Depth	Permit number	Easting	Northing	Exclusion zone
Ningaloo Vision FPSO	341 m	WA-35-L	21°24'12.39"	114°05'17.22"	500m plus 2.5 nm cautionary zone



Activity overview cont.

+ Production

The *Ningaloo Vision* FPSO has purpose-built topside facilities which separate, stabilise and dehydrate the crude oil and gas produced from the Coniston, Novara and Van Gogh fields. The FPSO has a design processing capacity is 150,000 barrels of liquids per day, including 63,000 barrels of oil.

Oil is periodically offloaded to tankers via a stern mounted offtake hose and gas produced on the FPSO is used for power generation with the excess gas being reinjected into the field.

The *Ningaloo Vision* FPSO has not discharged produced formation water (PFW) overboard to date. However, PFW may be discharged to the marine environment in the event that the PFW injection system is partly or wholly unavailable.

The FPSO has the ability to suspend production and disconnect from its turret mooring and leave the field for major shipyard works, or cyclone/adverse weather avoidance. The *Ningaloo Vision* FPSO is due to disconnect and sail away in Q1 of 2020, to undergo a planned dry dock and maintenance program.

Operations of the *Ningaloo Vision* FPSO is supported by infield support and supply vessels as well as helicopters for crew transfer and emergency situations.

+ Facility and subsea Inspection, maintenance and repair activities

To support the *Ningaloo Vision* FPSO's ongoing safe and reliable operations, inspection, maintenance and repair activities are regularly conducted to ensure safe and reliable operations.

These activities may require additional vessels in the field. If activities have the potential to result in significant change to the facility or to environmental or social impacts, additional stakeholder engagement or environmental approvals may be required.

+ Projects

Project activities may be required for the purposes of refurbishment, modification or major maintenance activities on the facility or subsea infrastructure. If a project scope has the potential to result in significant change to the approved activities, risks or impacts, an assessment of whether an Environment Plan revision is required will be undertaken

+ Well abandonment and decommissioning activities

Decommissioning and well abandonment activities are not included in this Environment Plan. When required, decommissioning and well abandonment would be the subject of additional stakeholder engagement and environmental approvals.

Minor infrastructure removal and replacement will be allowed for within this Environment Plan.

Approximate distances to key regional features

Cape Range Peninsula	45 km	Ningaloo Marine Park (Northern Boundary)	29 km
Exmouth Township	57 km	State/ Commonwealth waters boundary	33 km

Environmental management

Santos understands retaining a broad licence to operate depends on the development and maintenance of positive and constructive relationships with a comprehensive set of stakeholders. To allow an informed assessment by stakeholders of the potential impact of Santos' activities at the *Ningaloo Vision* FPSO, this consultation material includes information on planned and unplanned events. In addition this table includes a high level overview of measures in place to manage or mitigate the associated impacts and risks.

Potential risks and/or impacts	Management measures
Waste management	+ Wastes will be managed and disposed of in a safe and environmentally responsible manner that prevents accidental loss to the environment in accordance with the Santos Waste Management Plan.
Light emissions	+ Lighting is minimised to that required for operational safety and navigational purposes.
Underwater noise impacts	+ Santos has measures in place for managing interaction with protected marine fauna as per the EPBC Regulations (Part 8).
Marine fauna interaction	+ Santos has measures in place for managing interaction with protected marine fauna as per the EPBC Regulations (Part 8).
Interactions with other marine users	+ Existing infrastructure is marked on nautical charts. + A 500 m petroleum safety zone is in place around the FPSO.
Invasive marine species	+ Vessels and equipment will be risk assessed and managed to reduce the risk of invasive marine species. + Santos contracted vessels comply with Australian ballast water requirements.
Disturbance to seabed	+ No anchoring activities take place in the Operational Area, by support / maintenance vessels or offtake tankers. + Adherence to lifting procedures, performance standards and safety case specific lifting requirements.
Planned discharges to the marine environment	+ Routine discharges (such as putrescible wastes, sewage, grey water, oily water, drainage, cooling water and brine) from the *Ningaloo Vision* FPSO and support vessels will meet legal requirements. + Chemical use will be managed in accordance with Santos' Chemical Selection Procedure + Under normal operating conditions, PFW is reinjected back into the reservoir, therefore minimising discharges to the marine environment + Any contingency PFW discharges (in the event that the PFW injection system is partly or wholly unavailable) will be managed through an adaptive management process, referred to as the PFW Monitoring and Management Strategy.

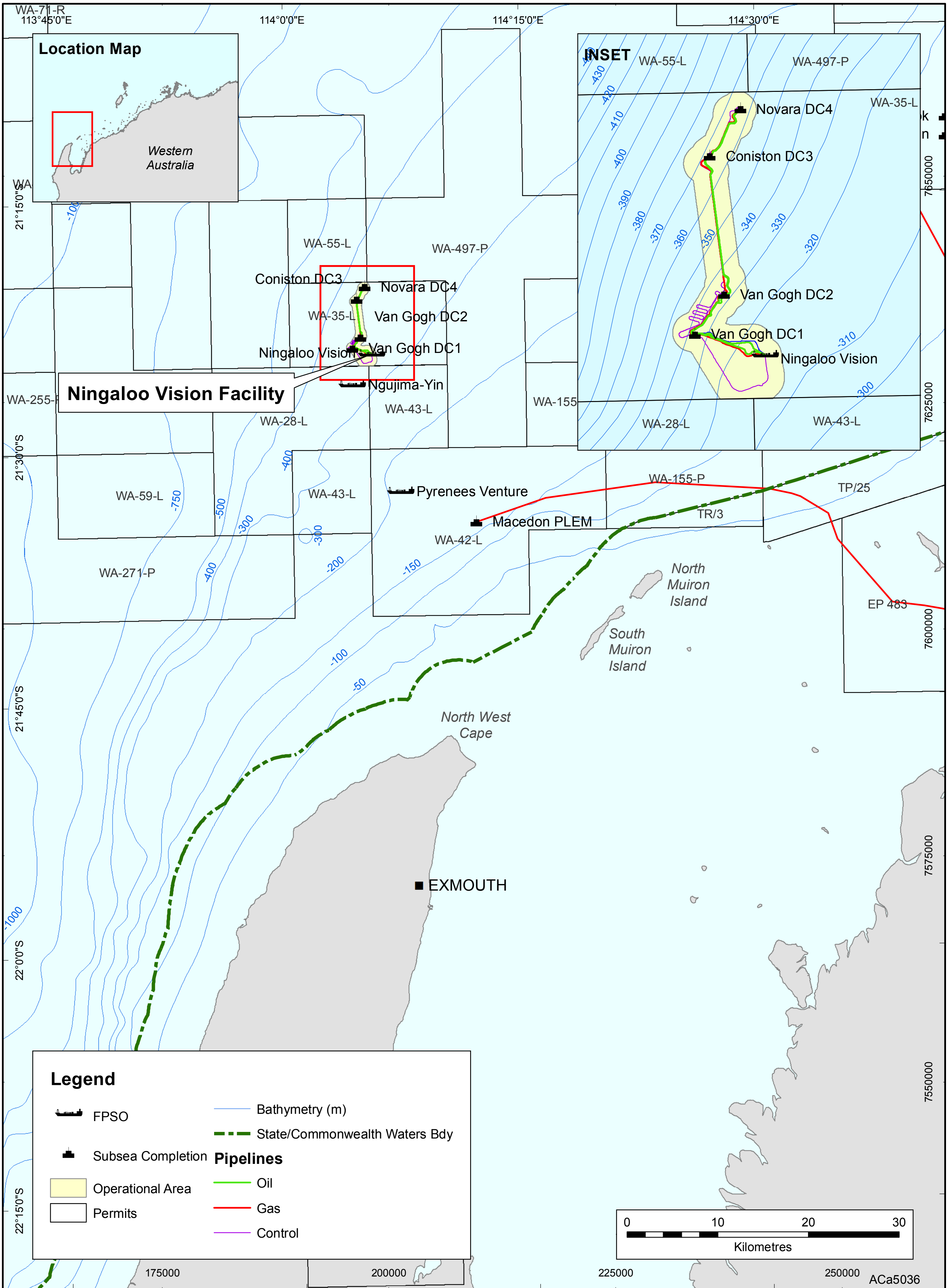
Atmospheric emissions	+ Gas flaring is managed to a level required for safe and efficient production. A maximum flaring volume per year will not be exceeded. + Emissions are reported in accordance with regulatory requirements + All vessels must follow relevant operating and maintenance procedures to minimised process upsets. + Support vessel emissions will comply with MARPOL Annex VI as per vessel class.
Unplanned releases including hydrocarbons	+ Standards and Procedures to reduce the potential for uncontrolled hydrocarbon releases will be followed. + Appropriate bunkering and oil offtake procedures and equipment will be implemented to prevent spills to the marine environment. + Appropriate spill response plans, equipment and materials will be in place and maintained.

Providing feedback

Prior to the submission of an Environment Plan, Santos must consult with 'relevant persons' whose functions, interests and activities may be affected by *Ningaloo Vision* Operations, and their feedback considered with the aim of avoiding, minimising or managing the impact of operations.

If you wish to discuss this consultation material further please provide comment as soon as practicable. All correspondence will be included in the Environment Plan submission to NOPSEMA, as required under the regulations.

[redacted]
Santos Limited
Ph: (08) [redacted]
Email: [redacted]



Santos

NINGALOO VISION FACILITY
LOCATION MAP

Ningaloo Vision Operations Environment Plan Revision

Santos Limited (Santos) is the operator of the *Ningaloo Vision* Floating, Production, Storage Offtake (FPSO) facility. The *Ningaloo Vision* FPSO stores and produces oil from the Van Gogh, Coniston and Novara fields in Commonwealth waters, approximately 57 km North of the Exmouth Township. Operations occur in water depths ranging from 340 m in the east of production licence WA-35-L, to 400 m depth in the west.

Background

Petroleum activities in Commonwealth waters are regulated by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), a Commonwealth statutory authority.

Before Santos can undertake a petroleum activity (including operating a facility), our plan for managing the environment (the Environment Plan) must be accepted by NOPSEMA in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009). The current revision of the *Ningaloo Vision Operations Environment Plan* was accepted by NOPSEMA in 2015.

This consultation package relates to the five-yearly revision of the *Ningaloo Vision Operations Environment Plan,* required in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009).

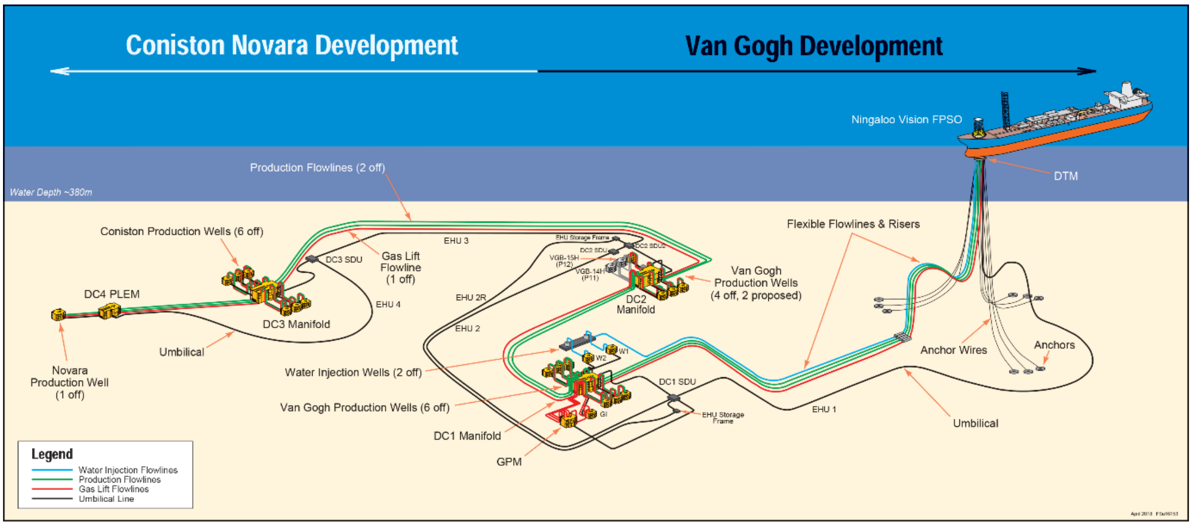
Activity overview

The Van Gogh, Coniston and Novara field subsea production system includes oil production, gas injection and water reinjection wells, and subsea manifolds connected to the FPSO via flexible flowlines and risers. Oil has been recovered from the Van Gogh field using the *Ningaloo Vision* FPSO since 2009/10 and comingled with oil from the Coniston and Novara fields since 2015.

The Environment Plan Operational Area (see map on page 5) is defined as the area within the 500 m Petroleum Exclusion Zone that extends around the *Ningaloo Vision* FPSO (whilst at mooring), the Detachable Turret Mooring, anchor spread and all other subsea infrastructure of the Coniston, Novara and Van Gogh Developments.

The estimated operational life of the Van Gogh, Coniston and Novara fields is 15 to 20 years.

Facility	Water Depth	Permit number	Easting	Northing	Exclusion zone
Ningaloo Vision FPSO	341 m	WA-35-L	21°24'12.39"	114°05'17.22"	500m plus 2.5 nm cautionary zone



Activity overview cont.

+ Production

The *Ningaloo Vision* FPSO has purpose-built topside facilities which separate, stabilise and dehydrate the crude oil and gas produced from the Coniston, Novara and Van Gogh fields. The FPSO has a design processing capacity of 150,000 barrels of liquids per day, including 63,000 barrels of oil.

Oil is periodically offloaded to tankers via a stern mounted offtake hose and gas produced on the FPSO is used for power generation with the excess gas being reinjected into the field.

While the current in-force EP allows for contingent overboard discharge of produced water (PW), the *Ningaloo Vision* FPSO has not discharged PW to the marine environment to date. The next revision of the EP will also include contingency to discharge PW under a range of scenarios in order to continue and maintain production. In such circumstances, measures will be in place to ensure that the volume and quality of PW is within acceptable limits and that effective monitoring actions are implemented.

The FPSO has the ability to suspend production and disconnect from its turret mooring and leave the field for major shipyard works, or cyclone/adverse weather avoidance. The *Ningaloo Vision* FPSO is due to disconnect and sail away in Q2 of 2020, to undergo a planned dry dock and maintenance program.

Operations of the *Ningaloo Vision* FPSO is supported by infield support and supply vessels as well as helicopters for crew transfer and emergency situations.

+ Facility and subsea Inspection, maintenance and repair activities

To support the *Ningaloo Vision* FPSO's ongoing safe and reliable operations, inspection, maintenance and repair activities are regularly conducted to ensure safe and reliable operations.

These activities may require additional vessels in the field. If activities have the potential to result in significant change to the facility or to environmental or social impacts, additional stakeholder engagement or environmental approvals may be required.

+ Projects

Project activities may be required for the purposes of refurbishment, modification or major maintenance activities on the facility or subsea infrastructure. If a project scope has the potential to result in significant change to the approved activities, risks or impacts, an assessment of whether an Environment Plan revision is required will be undertaken.

+ Well abandonment and decommissioning activities

Decommissioning and well abandonment activities are not included in this Environment Plan. When required, decommissioning and well abandonment would be the subject of additional stakeholder engagement and environmental approvals.

Minor infrastructure removal and replacement will be allowed for within this Environment Plan.

Approximate distances to key regional features

Cape Range Peninsula	45 km	Ningaloo Marine Park (Northern Boundary)	29 km
Exmouth Township	57 km	State/ Commonwealth waters boundary	33 km

Environmental management

Santos understands retaining a broad licence to operate depends on the development and maintenance of positive and constructive relationships with a comprehensive set of stakeholders. To allow an informed assessment by stakeholders of the potential impact of Santos' activities at the *Ningaloo Vision* FPSO, this consultation material includes information on planned and unplanned events. In addition, this table includes a high level overview of measures in place to manage or mitigate the associated impacts and risks.

Potential risks and/or impacts	Management measures
Waste management	+ Wastes will be managed and disposed of in a safe and environmentally responsible manner that prevents accidental loss to the environment in accordance with a waste management procedure and legislated requirements.
Light emissions	+ Lighting is minimised to that required for operational safety and navigational purposes.
Underwater noise impacts	+ Santos has measures in place for managing interaction with protected marine fauna as per the EPBC Regulations (Part 8).
Marine fauna interaction	+ Santos has measures in place for managing interaction with protected marine fauna as per the EPBC Regulations (Part 8).
Interactions with other marine users	+ Existing infrastructure is marked on nautical charts. + A 500 m petroleum safety zone is in place around the FPSO.
Invasive marine species	+ Vessels and equipment will be risk assessed and managed to reduce the risk of invasive marine species. + Santos contracted vessels comply with Australian ballast water requirements.
Disturbance to seabed	+ No anchoring activities take place in the Operational Area, by support / maintenance vessels or offtake tankers. + Adherence to lifting procedures, performance standards and safety case specific lifting requirements.
Planned discharges to the marine environment	+ Routine discharges (such as putrescible wastes, sewage, grey water, oily water, drainage, cooling water and brine) from the *Ningaloo Vision* FPSO and support vessels will meet legal requirements. + Chemical use will be managed in accordance with Santos' Chemical Selection Procedure. + PW is preferentially reinjected into the reservoir, however, discharge to the marine environment may be required. Under these circumstances, controls are in place to monitor and adjust the volume and quantity of PW discharged to within acceptable limits.

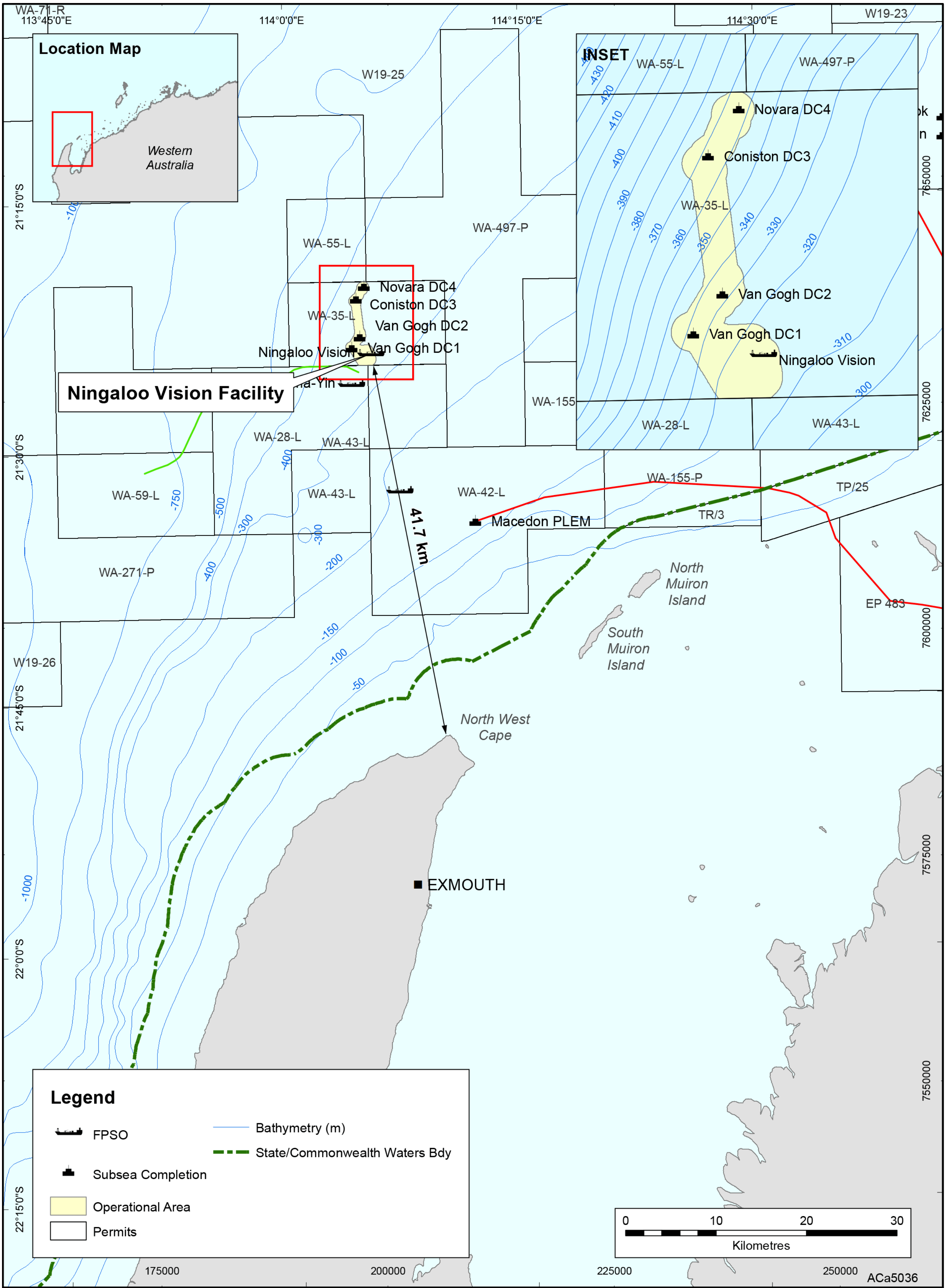
Atmospheric emissions	+ Gas flaring is managed to a level required for safe and efficient production. Volumes and efficiencies of atmospheric emissions are managed in accordance with the Clean Energy Act. + Emissions are reported in accordance with regulatory requirements + All vessels must follow relevant operating and maintenance procedures to minimise process upsets. + Support vessel emissions will comply with MARPOL Annex VI as per vessel class.
Unplanned releases including hydrocarbons	+ Standards and Procedures to reduce the potential for uncontrolled hydrocarbon releases will be followed. + Appropriate bunkering and oil offtake procedures and equipment will be implemented to prevent spills to the marine environment. + Appropriate spill response plans, equipment and materials will be in place and maintained.

Providing feedback

Prior to the submission of an Environment Plan, Santos must consult with 'relevant persons' whose functions, interests and activities may be affected by *Ningaloo Vision* Operations, and their feedback considered with the aim of avoiding, minimising or managing the impact of operations.

If you wish to discuss this consultation material further, please provide comment as soon as practicable. All correspondence will be included in the Environment Plan submission to NOPSEMA, as required under the regulations.

[redacted]
Santos Limited
Ph: (08) [redacted]
Email: [redacted]



Santos

NINGALOO VISION FACILITY
LOCATION MAP

Santos

STAKEHOLDER CONSULTATION

Quarterly

Consultation Updates

Quarterly Consultation Update

January 2020

This update outlines planned activities by Santos Limited (Santos) in Western Australia through Q1 2020 to Q2 2020. It is intended to provide advance notification to enable stakeholders to identify activities that may impact them, or for which more information is sought.

This document is provided in accordance with State and Commonwealth regulatory consultation guidelines, and can be supplemented with detailed project information packages or briefing sessions from Santos by request, using the contact details provided below.

Please note that scheduling of the activities described in this update is subject to vessel and equipment availability and receipt of all necessary approvals, therefore the timing indicated may be subject to change. If there are any significant changes made to the scheduling indicated, stakeholders will be advised.

A summary of Santos' current operating facilities is also provided.

The spatial locations of activities described throughout this document can be found in the tables within, and in figures at the end of, this update.

Potential impact to stakeholder interests

When reviewing Santos' activities within this document, please consider how they may impact your area of interest as an individual stakeholder.

Impacts to stakeholders may include exclusion zones for short and long term projects. For example, the gazetted exclusion zone around a drilling rig is 500 metres (m), while the exclusion zone around a slow-moving vessel, towing seismic streamers, can be larger.

This may impact access to an area by mariners during a proposed activity. Santos recommends stakeholders assess all information provided and seek additional information if required.

Operational activities relate to operations at the Varanus Island, Burrup Pipeline, Devil Creek and the *Ningaloo Vision* Floating Production Storage and Offloading (FPSO) facilities. These facilities have an existing exclusion zone which has been in place for an extended period of time.

Thank you for taking the time to review this update. Stakeholder feedback is valuable before, during and after activities, so if you have any concerns or queries relating to the activities described in this document, please feel free to contact us at the email below.

Contact Us
Santos
Ph: [redacted]
Email: [redacted]
Web: http://Santos.com/

Santos

Proposed Western Australia offshore activities

This table gives key information on upcoming activities that are proposed to occur from Q1 2020

Activity Name	Type of Activity	Permit Number	Latitude	Longitude	Water Depth (approx.)	Start date estimate	End date estimate	Exclusion zone details
***Ningaloo Vision* FPSO** (Commonwealth Waters)	Shipyard Campaign (International)	WA-35-L	Coordinates available on request		N/A	Planned departure Q2 2020	Estimated return Q3/Q4 2020	500m while on station
Keraudren Extension (Commonwealth Waters)	Seismic Survey	WA-435-P WA-436-P WA-437-P WA-438-P	Coordinates available on request		>50 – 200 m	Q2 2020	31July 2020 (Stage 1)	3 nautical miles around vessel
Yoorn-1 (Commonwealth and State waters)	Geophysical & Geotechnical Site Survey	WA-499-P TL-5 TP-27 TP-8	Coordinates available on request		40 – 50 m	Window between Q2 2020 to Q2 2021	2-10 days after start date	500m around survey vessel
Yoorn-1 (Commonwealth waters)	Exploration Drilling	WA-499-P	20° 20' 32" S	115° 47' 14" E	40 – 50 m	Window between Q4 2020 to Q3 2021	Estimated completion up to 60 days after start date	500m around MODU

Current offshore activities

Santos provides an update on ongoing activities in Q1 2020.

Activity Name	Type of Activity	Permit Number	Latitude	Longitude	Water Depth (approx.)	Start date	End date estimate	Exclusion zone details
Varanus Island Power Optimisation Project (Onshore)	Compression Facility Installation	PL-29 PL-12	Coordinates available on request		N/A	Commenced Q3 2019	Estimated Completion Q1/Q2 2021	N/A

Completed offshore activities

Santos provides an update on activities previously consulted and now completed.

Activity Name	Type of Activity	Permit Number	Water Depth	Latitude	Longitude
Van Gogh Field (Commonwealth Waters)	Inspection Maintenance and Repair (IMR)	WA-35-L	340 m	21° 20' 57.29"S	114° 04' 23.613" E
John Brookes / Greater East Spar (Commonwealth waters)	Inspection Maintenance and Repair (IMR)	WA-29-L WA-45-L	48 – 110 m	115° 07' 12.624 E 114° 54' 22.08 E	20° 26' 50.445 S 20° 36' 31.95 S

Santos

Santos' West Australian operations

Santos provides an overview of existing operations on the North West Shelf.

Operational Activity Name	Type of Activity	Water depth	Exclusion zone	Update
Devil Creek Gas Plant (Reindeer facility, pipeline and gas plant)	Gas Production	Reindeer platform at 61 m	500 m around Reindeer Platform	Ongoing operations The five yearly regulatory revision of the two Environment Plans (EPs) which govern activities for the Reindeer Wellhead Platform and associated infrastructure have been completed and submitted to the regulators.
Varanus Island Hub (State and Commonwealth waters)	Oil & Gas Production	Various offshore platforms from	500 m around all offshore platforms (coordinates available on request)	Ongoing operations Environmental monitoring program ongoing at Varanus Island. The five yearly regulatory revision of the two Environment Plans (EPs) which govern activities at the Varanus Island Hub have been completed and submitted to the regulators.
Mutineer-Exeter Field	Ceased production	130 – 160 m	None	Production from the field has ceased and subsea infrastructure is currently preserved.
Burrup Lateral Gas	Gas Supply	Onshore	Onshore	Ongoing operations.
***Ningaloo Vision* FPSO**	Oil Production	340 m	500 m around FPSO	Ongoing operations. The five yearly regulatory revision of the *Ningaloo Vision* Operations Environment Plan (EP) is currently underway and due for submission Q2 2020.

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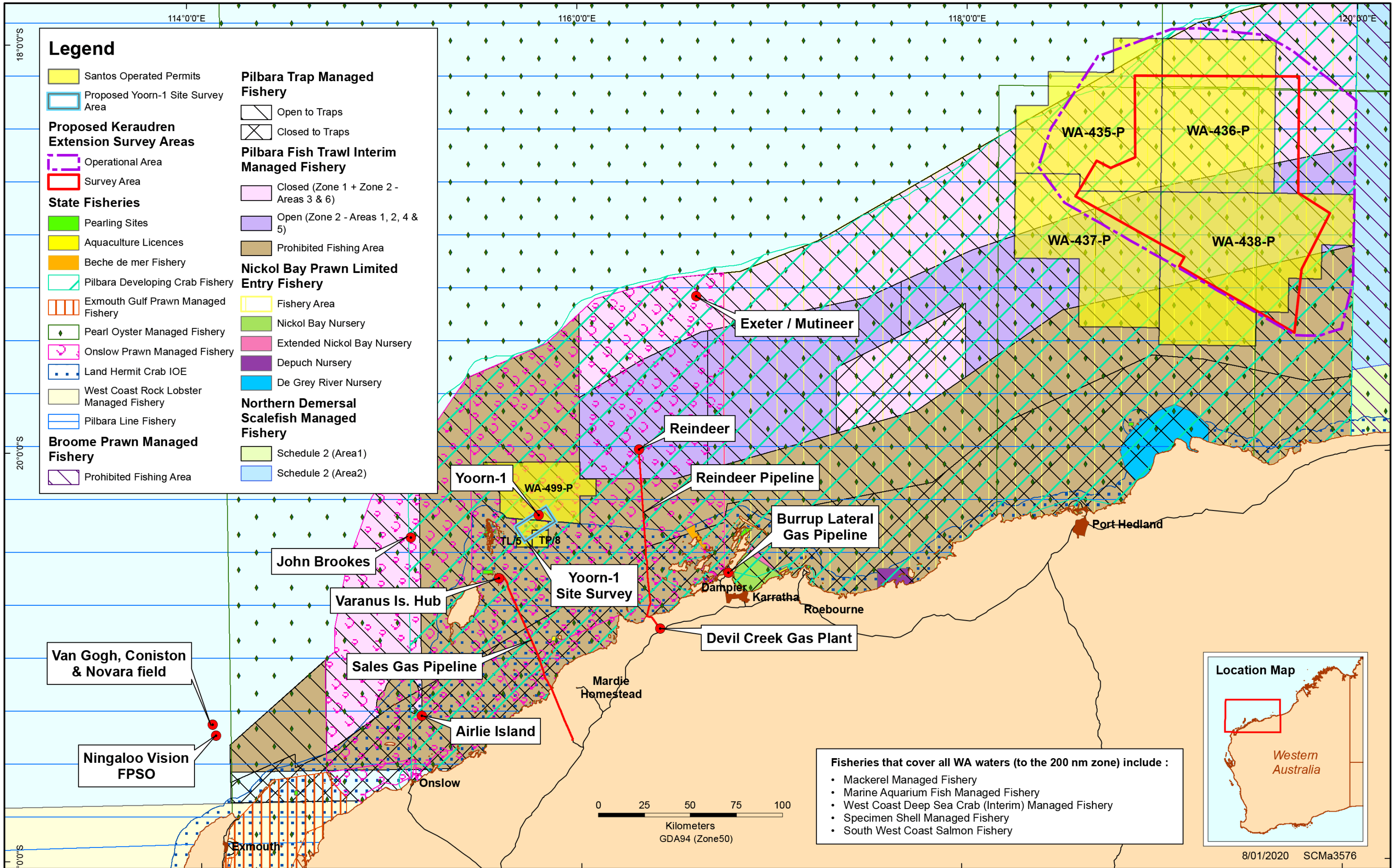

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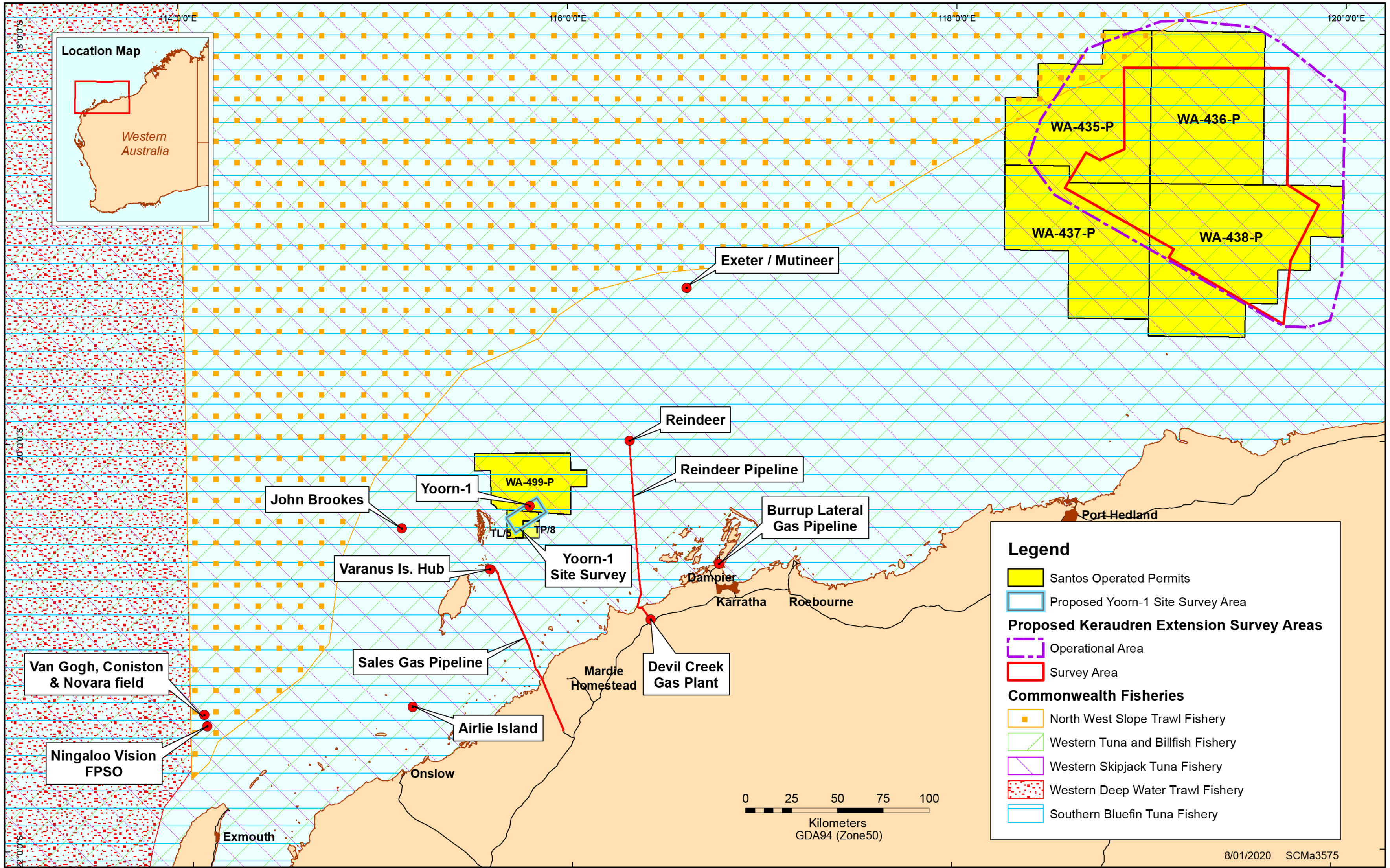
WESTERN AUSTRALIAN SANTOS ACTIVITIES
STATE FISHING ZONES

Santos



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WESTERN AUSTRALIAN SANTOS ACTIVITIES
COMMONWEALTH FISHING ZONES

Appendix F. Environmental Consequence Descriptors

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Consequence Level		I	II	III	IV	V	VI
Acceptability		Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Severity Description		**Negligible** ***No impact or negligible impact.***	**Minor** ***Detectable but insignificant change to local population, industry or ecosystem factors. Localised effect***	**Moderate** ***Significant impact to local population, industry or ecosystem factors.***	**Major** ***Major long-term effect on local population, industry or ecosystem factors.***	**Severe** ***Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.***	**Critical** ***Irreversible impact to regional population, industry or ecosystem factors.***
Environmental Receptors	**Fauna** In particular, EPBC Act listed threatened/migratory fauna or WA Biodiversity Conservation Act 2016 specially protected fauna	Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity; No decrease in local population size; No reduction in area of occupancy of species; No loss/disruption of habitat critical to survival of a species; No disruption to the breeding cycle of any individual; No introduction of disease likely to cause a detectable population decline.	Detectable but insignificant decrease in local population size; Insignificant reduction in area of occupancy of species; Insignificant loss/disruption of habitat critical to survival of a species; Insignificant disruption to the breeding cycle of local population.	Significant decrease in local population size but no threat to overall population viability; Significant behavioural disruption to local population; Significant disruption to the breeding cycle of a local population; Significant reduction in area of occupancy of species; Significant loss of habitat critical to survival of a species; Modify, destroy, remove, isolate or decrease availability of quality of habitat to the extent that a significant decline in local population is likely; Introduce disease likely to cause a significant population decline.	Long term decrease in local population size and threat to local population viability; Major disruption to the breeding cycle of local population; Major reduction in area of occupancy of species; Fragmentation of existing population; Major loss of habitat critical to survival of a species; Modify, destroy, remove, isolate or decrease availability of quality of habitat to the extent that a long term decline in local population is likely; Introduce disease likely to cause a long term population decline.	Complete loss of local population; Complete loss of habitat critical to survival of local population; Wide spread (regional) decline in population size or habitat critical to regional population.	Complete loss of regional population; Complete loss of habitat critical to survival of regional population.
Environmental Receptors	**Physical Environment / Habitat** Includes: air quality; water quality; benthic habitat (biotic/abiotic), particularly habitats that are rare or unique; habitat that represents a Key Ecological Feature[8]; habitat within a protected area; habitats that include benthic primary producers[9] and/ or epi-fauna[10]	No or negligible reduction in physical environment / habitat area/function.	Detectable but localised and insignificant loss of area/function of physical environment / habitat. Rapid recovery evident within ~ 2 year (two season recovery)	Significant loss of area and/or function of local physical environment / habitat. Recovery over medium term (2–10 years)	Major, large-scale loss of area and/or function of physical environment / local habitat. Slow recovery over decades.	Extensive destruction of local physical environment / habitat with no recovery; Long term (decades) and wide spread loss of area or function of primary producers on a regional scale.	Complete destruction of regional physical environment / habitat with no recovery. Complete loss of area or function of primary producers on a regional scale.
Environmental Receptors	**Threatened ecological communities** (EPBC Act listed ecological communities)	No decline in threatened ecological community population size, diversity or function; No reduction in area of threatened ecological community; No introduction of disease likely to cause decline in threatened ecological community population size, diversity or function.	Detectable but insignificant decline in threatened ecological community population size, diversity or function; Insignificant reduction in area of threatened ecological community.	Significant decline in threatened ecological community population size, diversity or function; Significant reduction in area of threatened ecological community; Introduction of disease likely to cause significant decline in threatened ecological community population size, diversity or function.	Major, long term decline in threatened ecological community population size, diversity or function; Major reduction in area of threatened ecological community; Fragmentation of threatened ecological community; Introduce disease likely to cause long term decline in threatened ecological	Extensive, long term decline in threatened ecological community population size, diversity or function; Complete loss of threatened ecological community.	Complete loss of threatened ecological community with no recovery.

[8] As defined by the Department of Agriculture, Water and Environment (DaWE)

[9] Benthic photosynthetic organisms such as seagrass, algae, hard corals and mangroves

[10] Fauna attached to the substrate including sponges, soft corals and crinoids.

Consequence Level		I	II	III	IV	V	VI
Acceptability		Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Severity Description		**Negligible** ***No impact or negligible impact.***	**Minor** ***Detectable but insignificant change to local population, industry or ecosystem factors. Localised effect***	**Moderate** ***Significant impact to local population, industry or ecosystem factors.***	**Major** ***Major long-term effect on local population, industry or ecosystem factors.***	**Severe** ***Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.***	**Critical** ***Irreversible impact to regional population, industry or ecosystem factors.***
					community population size, diversity or function.		
	Protected Areas Includes: World Heritage Properties; Ramsar wetlands; Commonwealth/ National Heritage Areas; Land/ Marine Conservation Reserves.	No or negligible impact on protected area values; No decline in species population within protected area; No or negligible alteration, modification, obscuring or diminishing of protected area values.*	Detectable but insignificant impact on one of more of protected area's values. Detectable but insignificant decline in species population within protected area. Detectable but insignificant alteration, modification, obscuring or diminishing of protected area values*	Significant impact on one of more of protected area's values; Significant decrease in population within protected area; Significant alteration, modification, obscuring or diminishing of protected area values.	Major long term effect on one of more of protected area's values Long term decrease in species population contained within protected area and threat to that population's viability Major alteration, modification, obscuring or diminishing of protected area values	Extensive loss of one or more of protected area's values; Extensive loss of species population contained within protected area.	Complete loss of one or more of protected area's values with no recovery; Complete loss of species population contained within protected area with no recovery.
	Socio-economic receptors Includes: fisheries (commercial and recreational); tourism; oil and gas; defence; commercial shipping.	No or negligible loss of value of the local industry; No or negligible reduction in key natural features or populations supporting the activity.	Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.	Significant loss of value of the local industry; Significant medium term reduction of key natural features or populations supporting the local activity.	Major long-term loss of value of the local industry and threat to viability. Major reduction of key natural features or populations supporting the local activity.	Shutdown of local industry or widespread major damage to regional industry; Extensive loss of key natural features or populations supporting the local industry.	Permanent shutdown of local or regional industry; Permanent loss of key natural features or populations supporting the local or regional industry.

Appendix G. Produced Water Properties

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1 Produced Water Properties

PW is comprised mainly of water with small amounts of contaminants including dispersed oil, organic and inorganic compounds, metals, radioisotopes and residual process chemicals. The PW properties are based on production from the Van Gogh, Coniston and Novara reservoirs.

Analysis of PW, has been routinely undertaken by an independent laboratory (approximately every 6 months). This analysis includes the following contaminants of concern:

+ Oil in water (OIW);
+ Aromatic hydrocarbons as a component of OIW;
+ Trace metals and nutrients; and
+ Naturally occurring radioactive materials (NORMs).

Properties of PW determined by most recent laboratory analysis undertaken between April 2016 and December 2019 are presented in **Table 1-1.** Sampling in December 2019 included two taken samples, one at 30.5 mg/l OIW (referenced as Low OIW) and one at 74.5 mg/l OIW (referenced as High OIW) (Intertek, 2019b).

PW analysis results were compared with ANZECC/ARMCANZ 99% and 95% species protection values. Note: PW was not dicharged to the marine environment during the period April 2016 and December 2019.

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Table 1-1: Produced Water chemical composition (2016-2019)

Analyte		ANZECC Guidelines		Concentration (mg/L)										
		95%	99%	2016 (Apr)	2016 (Sept)	2017 (May)	2017 (Oct)	2018 (Mar)	2018 (Sept)	2019 (Mar)	2019 (Aug)	2019 (Aug)	2019 (Dec)	2019 (Dec)
pH		-	-	**6.6**	**6.7**	**6.8**	**6.6**	**6.6**	**6.6**	**7.3**	**6.9**	**6.9**	**7.3**	**8.3**
Oil and grease		-	-	**80**	**32**	**16**	**27**	**24**	**45**	**23**	**64**	**67**	**11**	**21**
Oil in Water - UV/Vis		-	-	**42**	**17**	**27**	**33**	**37**	**55**	**34**	**58**	**66**	**30.5**	**74.5**
Total Petroleum hydrocarbons	C 6-9	-	-	<0.02	<0.02	0.05	<0.02	0.10	<0.02	<0.02	<0.02	<0.02	<0.05	<0.05
	C 10-14	-	-	0.57	2	1.1	2.1	1.2	7.2	2.3	4.5	4.8	0.39	0.7
	C 15-28	-	-	8.05	27	13	28	18	87	28	49	55	5.1	10
	C 29-36	-	-	1.9	7	2.8	9.0	5.6	22	6.3	15	16	1.6	3.3
	C 6-36	-	-	10.5	38.22	17	3.4	25	120	37	68.5	75.8	7.1	14
BTEX	Benzene	0.7	0.5	0.001	0.002	0.003	0.001	0.018	<0.01	<0.001	<0.001	<0.001	<0.003	<0.003
	Toluene	-	-	0.0015	0.005	0.005	0.002	0.029	<0.01	0.001	<0.001	<0.001	<0.003	<0.003
	Ethyl-Benzene	-	-	0.001	0.001	0.001	<0.001	0.006	<0.01	<0.001	<0.001	<0.001	<0.003	<0.003
	Xylene	-	-	0.003	0.005	0.006	<0.003	0.042	<0.03	<0.003	<0.003	<0.003	<0.003	<0.006
	Sum BTEX	-	-	0.0025	0.012	0.015	0.003	0.095	<0.06	<0.006	<0.006	<0.006	<0.012	<0.015
PAHs	Naphthalene	-	-	0.002	0.0001	0.006	0.0003	0.0012	0.0014	0.0006	<0.0001	<0.0001	0.0008	0.0009
	Acenaphthylene	-	-	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Acenaphthene	-	-	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Fluorene	-	-	<0.0001	<0.0001	0.0002	0.0002	0.0004	0.0005	0.0002	0.0004	0.0004	<0.0001	<0.0002
	Phenathrene	-	-	0.0038	0.0001	0.0012	0.0012	0.0017	0.0026	<0.0001	0.0046	0.0049	0.0006	0.001
	Anthracene	-	-	0.0001	0.0001	<0.0001	0.0002	0.0001	<0.0001	0.0007	0.0003	0.0004	<0.0001	<0.0001
	Fluoranthene	-	-	0.0001	0.0001	<0.0001	0.0004	0.0002	0.0004	<0.0001	0.0005	0.0005	<0.0001	<0.0001

Analyte		ANZECC Guidelines		Concentration (mg/L)										
		95%	99%	2016 (Apr)	2016 (Sept)	2017 (May)	2017 (Oct)	2018 (Mar)	2018 (Sept)	2019 (Mar)	2019 (Aug)	2019 (Aug)	2019 (Dec)	2019 (Dec)
	Pyrene	-	-	0.0001	0.0001	<0.0001	0.0003	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chrysene	-	-	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nutrients	Ammonia – N	0.91	0.39	19	20	19	20	18	21	18	19	18	N/A	N/A
	NOx – N	-	-	<0.01	<0.01	<0.01	0.02	<0.01	0.08	<0.01	<0.01	<0.01	N/A	N/A
	Total Kjeldahl Nitrogen	-	-	19	20	19	24	19	21	19	19	18	N/A	N/A
	Total Nitrogen	-	-	19	20	19	24	19	21	19	19	18	N/A	N/A
	Total Phosphorus	-	-	0.455	0.42	1.6	0.35	0.37	0.50	0.50	0.39	0.35	N/A	N/A
COD and solids	Chemical Oxygen Demand	-	-	940	260	740	310	110	700	40	170	130	N/A	N/A
	Total Dissolved Solids	-	-	36,000	36,000	39,000	35,000	35,000	35,000	31,000	37,000	38,000	N/A	N/A
	Total Suspended Solids	-	-	8	9	<5	<5	<5	9	<5	10	15	N/A	N/A
	Total Organic Carbon	-	-	103.5	16	66	17	12	18	4	3	3	N/A	N/A
Metals	Arsenic-dissolved	-	-	0.001	0.009	0.005	0.003	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
	Barium dissolved	-	-	10.5	6.4	11	7.0	11	11	0.01	9.2	9.1	12.91	12.69
	Cadmium-dissolved	0.0055	0.007	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0002	<0.0002
	Chromium-dissolved	0.0044	0.00014	0.01	0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.2	<0.2
	Copper-dissolved	0.0013	0.0003	0.001	0.001	<0.001	0.004	0.005	0.014	0.001	0.018	0.023	<0.1	<0.1
	Iron-dissolved	-	-	0.115	0.06	0.12	0.02	0.04	0.05	0.01	<0.001	0.001	<0. 1	<0.1
	Manganese-dissolved	-	-	0.51	0.68	0.50	0.40	0.64	0.66	0.01	0.62	0.63	0.5	0.5
	Mercury-dissolved	-	-	0.00015	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0002	<0.001	<0.001
	Nickel dissolved	0.070	0.007	0.003	0.006	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.0001	<0.0001

Analyte		ANZECC Guidelines		Concentration (mg/L)										
		95%	99%	2016 (Apr)	2016 (Sept)	2017 (May)	2017 (Oct)	2018 (Mar)	2018 (Sept)	2019 (Mar)	2019 (Aug)	2019 (Aug)	2019 (Dec)	2019 (Dec)
	Lead dissolved	0.0044	0.0024	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.005	<0.005
	Zinc- dissolved	0.015	0.007	0.005	0.005	<0.005	<0.005	<0.005	0.010	0.005	0.005	0.008	<0.01	<0.01
Radionuclides	Radium 226	-	-	N/A	N/A	7.14 Bq/L	0.34 Bq/L	0.05 Bq/L	0.05 Bq/L	0.05 Bq/L	7.3 Bq/L	8.1 Bq/L	N/A	N/A
	Radium 228	-	-	N/A	N/A	12.8 Bq/L	2.73 Bq/L	0.08 Bq/L	0.08 Bq/L	0.08 Bq/L	15.8 Bq/L	15 Bq/L	N/A	N/A

NA= not analysed

Hydrocarbons

Historical analysis of PW has shown OIW content, as determined by spectrophotometry, to average 43 mg/L with maximum and minimum readings from sampling ranging between 74.5 mg/L (recorded in December 2019) and 16 mg/L (recorded in May 2017). Note: PW was not discharged to the marine environment during this period.

Benzene is the only BTEX (benzene, toluene, ethylbenzene xylene) analyte with an ANZECC species protection value for comparison, results in all years were well below the 95% and 99% species protection values.

Dissolved metals

The type and concentration of trace metals within PW depend upon the geology of the formation from which hydrocarbons are produced (Neff *et al.*, 2011). The metals most frequently found at elevated concentrations in PW include barium, iron, manganese, mercury and zinc (Neff *et al.*, 2011). Concentrations of dissolved trace metals within the PW are described in **Table 1-1** to allow for comparison of values against the ANZECC species protection values as there are no guidelines for total metals in marine waters.

Dissolved copper exceeded ANZECC 95% and 99% species protection values in 2018, dissolved zinc exceeded 99% species protection values in 2018 and 2019 but values were below 95% species protection values. Chromium exceeded the 95% and 99% species protection values in 2016 and December 2019.

Nutrients

Ammonia is the only nutrient with an ANZECC species protection value for comparison. All ammonia values exceeded the ANZECC 95% species protection values.

Naturally occurring radioactive materials (NORMs)

Naturally occurring radioactive materials (NORMs) are present within geological formations and are typically found in sand and produced water brought to the surface during production. Within produced water the most abundant radionuclides are ^{226}Ra and ^{228}Ra which are derived from the radioactive decay of ^{238}U and ^{232}Th, respectively (Bou-Rabee *et al.*, 2009). The half-lives of ^{226}Ra and ^{228}Ra are 1,601 and 5.7 years, respectively (Neff *et al.*, 2011). When PFW is brought to the surface with the oil, sand and gas, the rapid drop in temperature and pressure causes NORMs (primarily ^{226}Ra and ^{228}Ra) to precipitate out, which may result in accumulation of sludge and hard scales in the processing equipment (OGP, 2005). However, ^{226}Ra and ^{228}Ra may also remain dissolved within PW. Other radionuclides have been identified in PW including ^{212}Bi, ^{214}Bi, ^{228}Ac, ^{210}Pb, ^{212}Pb and ^{214}Pb, however, activities of these radionuclides are typically lower in PW than that of ^{226}Ra and ^{228}Ra (Bou-Rabee *et al.*, 2009).

Results of PW monitoring show NORMS levels have decreased between 2017 and March 2019, However rose again in August 2019. In August 2019 levels were 8.1 Bq/L ^{226}Ra compared with 0.05 Bq/L^{226}Ra in March 2019. A review of the ^{226}Ra and ^{228}Ra concentrations in PFW by Neff *et al.* (2011) across discharges worldwide indicates that ^{226}Ra activity ranges from 0.002 to 1,119 Bq/L and ^{228}Ra activity ranges from 0.3 to 180 Bq/L. Natural levels within ocean surface waters of 0.001–0.0015 Bq/l and 0.0002–0.0011 Bq/L for ^{226}Ra and ^{228}Ra, respectively have been reported (Neff *et al.*, 2011).

Production chemicals

During the processing of hydrocarbons, production chemicals are used to aid in the recovery and separation of hydrocarbons from well fluids, and to protect production equipment. Production chemicals are evaluated and assessed in accordance with the *Operations Chemical Selection Evaluation and Approval Procedure (EA-91-II-1001*).

Production chemical concentrations within the December 2019 PW samples (Intertek, 2019b) are presented in **Table 1-2**.

Table 1-2: Production chemical concentrations for PW (December 2019)

Production Chemical	Concentration (mg/L)	
	Sample 1 – Low OIW	Sample 2 – High OIW
Oil in Water	30.5	74.5
MEG	1	4.3
TEG	<1	<1
Oxygen scavenger	<1	<1
Scale inhibitors	<0.1	<0.1
TEG corrosion inhibitor	<0.1	<0.1
TEG pH control	<0.1	<0.1
TEG antifoam	<0.1	<0.1
Diesel biocide	<0.01	<0.01
Process biocide (glutaraldehyde based)	0.01	0.02
Process biocide (THPS based)	<0.1	<0.1
H2S scavenger	<0.01	<0.01
Reverse emulsion breaker (clarifier)	<0.1	<0.1
Sodium carbonate	<1	<1
Chlorine scavenger	<1	<1
Sodium metabisulfite	<1	<1
Anti-scale	<1	<1

Whole of effluent toxicity

Santos used ecotoxicity testing to determine safe dilution factors of PW discharges for different levels of species protection. Ecotoxicity testing undertaken in December 2019 (Intertek, 2019c and Intertek, 2019d) was used to determine the dilution factors used in the method described in the Australian and New Zealand water quality guidelines (ANZECC/ARMCANZ, 2000 and ANZG (2018). Sampling and analysis was undertaken in December 2019 of PW collected from the produced water floatation unit. This is considered to be representative of what would be discharged under the scenarios described in the EP. However, the ecotoxicity testing results are conservative as OIW will be reduced to < 30 mg/L prior to discharge. The PW sample represents comingled discharge from Van Gogh, Coniston and Novara wells.

The selection of the test species for the ecotoxicity testing followed the protocol outlined in ANZECC/ARMCANZ (2000) and ANZG (2018). Results for the toxicity assessment testing undertaken in December 2019 are presented in **Table 1-3**.

Table 1-3: Ecotoxicity results for PW (December 2019)

Bioassay	Sample 1 – Low OIW				Sample 2 – High OIW			
	EC10 (%)	EC50 (%)	NOEC (%)	LOEC (%)	EC10 (%)	EC50 (%)	NOEC (%)	LOEC (%)
Microtox	27.8	>100	12.5	25	69.5	>100	50	100

Bioassay	Sample 1 – Low OIW				Sample 2 – High OIW			
	EC10 (%)	EC50 (%)	NOEC (%)	LOEC (%)	EC10 (%)	EC50 (%)	NOEC (%)	LOEC (%)
Microalgae Growth - *I. galbana*	41.5	70.4	50	100	53.5	76.7	50	100
Microalgae Growth - *N. closterium*	24.2	47.2	25	50	30.9	49.2	25	50
Mollusc Larvae Development	7.54	9.50	6.3	12.5	7.77	9.73	6.3	12.5
Sea Urchin Fertilisation	8.80	13.5	3.1	6.3	6.53	11.0	3.1	6.3
Sea Urchin Development	25.5	30.8	25	50	24.8	30.1	12.5	25
Copepod Larval Development[1]	11.9	20.7	<6.3	6.3	7.38	19.9	<6.3	6.3
Amphipod Survival[1]	17.9 (1.79)[2]	74.3	12.5	25	16.4 (1.64)[2]	>100	50	100
Fish Larvae Development	3.21	4.71	3.1	6.3	0.81	2.98	<1.6	1.6

1.Non-NATA Accredited Method

2.Input value for the species sensitivity distribution using the default acute to chronic conversion factor of 10

The no observed effect concentration (NOEC) results (i.e. raw data) for each test were used to derive the protective concentration (PC). The BurrliOZ™ software package was then used to calculate the species sensitivity distribution. The most conservative protective concentration of PC_{99} was used to generate safe dilution and dispersion boundaries for the discharge activity. The PC_{99} is expected to protect 99% of species in the ecosystem being considered. The protection of 99% of species maintains a high level of ecological protection at the boundary of the mixing zone.

A species sensitivity distribution was used to derive an ecological trigger value of 0.1% of PW sample to protect 99% of marine species. From the trigger value, a safe dilution of 1000:1 was determined as being needed to protect 99% protection of marine species for the Low OIW sample **(Table 1-4).** Concentrations in the below table have been used to inform the PFW mixing zone in Section 6.7 of the EP.

Table 1-4: Concentrations of the Van Gogh PW that would need to be met to ensure the protection of 99%, 95%, 90% and 80% of species and corresponding safe dilution factors (Low OIW)

Species Protection Level	Ningaloo Vision PW (% sample)	Safe Dilution Factor
PC_{80}*	4.5	22
PC_{90}*	1.9	52
PC_{95}*	0.78	128
PC_{99}*	0.1	1000

* PC refers to protection concentration. The number designates the % of species afforded protection if concentration does not exceed the value

Appendix H. Produced Water Adaptive Management Plan

Santos

1 Produced Water Adaptive Management Plan

As defined in **Section 6.7.1** of the EP, the scenarios for discharge of PW are:

+ **Scenario 1**: Planned reinjection into the reservoir (EP Table 6.17);
+ **Scenario 2**: Temporary planned discharges to the marine environment for maintenance activity purposes (with the intention to return to reinjection post maintenance activity) where inboarding of PW or full re-injection is not possible (EP Table 6.18);
+ **Scenario 3**: Temporary planned high oil in water discharge to the marine environment, limited to two specific events (with the intention to return to reinjection when upset condition resolved), preceded by a loss in PW injection capacity (EP Table 6.19);
+ **Scenario 4**: Temporary unplanned discharge to marine environment (with the intention to return to reinjection when upset condition resolved) (EP Table 6.20); and
+ **Scenario 5**: Permanent discharge to marine environment (EP Table 6.21).

1.1 Monitoring of Produced Water

Monitoring of Produced Water (PW) oil concentrations, physio-chemical stressors and toxicants is important to understand the potential for environmental impact from operations covered by this EP. The degree to which PW is monitored is dependent on the fate of PW (refer to **Section 6.7.1** of the EP) and the duration of discharge to the marine environment. Required routine monitoring of PW during the different PW discharge scenarios is described in **Table 1-1**.

Table 1-1: Routine PW Monitoring

Parameter	Method	Summary	Frequency
OIW concentrations	Inline OIW analyser	Provides continuous reading of PW OIW concentrations.	Continuous regardless of fate of PW.
	Onboard manual laboratory sampling of PW using a spectrophotometer	Verifies PW OIW concentrations taken from the inline OIW analyser.	**Reinjection** – sample is collected approximately every 12 hours. **Permanent and temporary discharge to the marine environment -** sample is collected approximately every 6 hours.
	NATA laboratory sampling	Verifies PW OIW concentrations from the inline OIW analyser and laboratory sampling of PW.	**Reinjection** – twice per year, approximately every 6 months. **Permanent and temporary discharge to the marine environment** - sample is collected within 30 days of discharge to the marine environment and then every 3 months whilst discharging.
Flow rate	3-hourly production averages	Provides continuous reading of PW discharge rates.	Continuous regardless of fate of PW.

Parameter	Method	Summary	Frequency
PW chemical characterisation[1]	NATA laboratory sampling	Monitors physio-chemical stressors such as metals/ammonia, OIW, residual process chemicals in the PW. Parameters tested are summarised in **Table 1-2**	**Reinjection** – twice/year, approximately every 6 months. **Permanent and temporary discharge to the marine environment** - sample is collected within 30 days of discharge to the marine environment and then (if applicable) approximately every 3 months whilst discharging.
	End of pipe PW sampling	End of pipe PW sampling provides an estimation of whether selected water quality parameters exceed trigger levels at the edge of the PW mixing zone. Parameters tested are summarised in **Table 1-3** and the process is defined in **Section 1.2.1.**	**Temporary discharge to the marine environment** - An assessment (see **Section 1.2.1**) is undertaken to asses if end of pipe PW sampling is required. **Permanent discharge to the marine environment** – NATA laboratory sampling approximately every 3 months whilst discharging (see above).
PW ecotoxicity[1]	Laboratory sampling of PW for ecotoxicity in accordance with ANZG (2018).	Monitors toxicity to marine species. Ecotoxicity testing in accordance with ANZG (2018).	**Reinjection** - sample is collected within two years of previous PW ecotoxicity testing results being available. **Temporary discharge to the marine environment** - An assessment is undertaken to assess if an ecotoxicity test on the PW is required. Factors considered include time since last ecotoxicity test, nature and scale of discharge, operational changes since previous PW chemical characterisation results. If assessment shows an increase in risk, ecotoxicity testing will be undertaken within 3 months of discharge. **Permanent discharge to the marine environment** - If no ecotoxicity tests within the last 6 months prior to discharge, then a sample for ecotoxicity testing is required to be taken within 3 months of the discharge and every 6 months thereafter.
Water quality – field monitoring [3]	Field monitoring – Dye test or equivalent[2]	Aids in validating predicted PW mixing zone. Sample of PW for chemical characterisation taken at the same time.	A dye test (or equivalent) with a PW stream discharge, will be undertaken within 6 months of permanent PW discharge, in a manner that represents a volume and rate based

Parameter	Method	Summary	Frequency
			on the reservoir characteristics and water cut at the time of the testing.
	Field monitoring – model validation	Validates predicted PW mixing zone by sampling water within and outside of the plume as indicated by dye or equivalent method.	**Temporary discharge to the marine environment** - An Assessment (see **Section 1.2.1**) is undertaken to asses if water quality sampling is required. **Permanent discharge to the marine environment** - For permanent discharge to the marine environment water quality sampling occurs within 6 months of discharge and then every 12 months thereafter.
Sediment quality and infauna monitoring [3]	Field monitoring - Baseline	Provides baseline data on sediment quality. Note: as of March 2020, PW has not been discharged from the Ningaloo Vision.	Within 12 months of EP acceptance prior to PW discharge.
	Field sediment monitoring	Validates modelled contaminant loadings in sediment by sampling sediments within and outside of the area predicted to receive measurable quantities of contaminants.	**Temporary discharge to the marine environment** - Undertaken when equivalent of 12 months full discharge over life of EP has occurred or once before expiry of EP, whichever is sooner. **Permanent discharge to the marine environment** Permanent discharge will be undertaken at 5 yearly intervals from discharge (e.g. once within the life of the EP).

[1] PW samples should be taken during representative routine operations. Where possible samples are taken at a time when all PW-producing wells are online.

[2] A dye test or equivalent is undertaken by discharging a dye through the PW system in a manner that represents a volume and rate based on the reservoir characteristics and water cut at the time of the testing. The dye indicates where the PW plume is, and is used to inform where water samples are taken, in order to validate the PW mixing zone boundary.

[3] The monitoring program for water quality and sediment quality is presented in Appendix I.

1.1.1 Parameters Measured During PW characterisation

1.1.1.1 NATA laboratory sampling (Routine)

Table 1-2 presents the parameters to be measured during PW characterisation (NATA laboratory sampling).

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Table 1-2: Parameters measured during PW characterisation (NATA laboratory sampling)

Parameters	
Organic analysis	
Hydrocarbons C 6–9	Surfactants
Hydrocarbons C 10–14	Total Organic Carbon
Hydrocarbons C 15–28	Chemical Oxygen Demand
Hydrocarbons C 29–36	Ammonia – N
Hydrocarbons > C36	Nitrate – N
Total Hydrocarbons C6–36	Total Kjeldahl Nitrogen – N
Oil and Grease	Total Nitrogen – N
Benzene	Tertiary Amines – N
Toluene	Total Phosphorous
Ethyl-Benzene	Total Dissolved Solids
Xylene	Total Suspended Solids
Sum of BTEX	pH
Acenaphthene	Total and dissolved Arsenic
Acenaphthalene	Total and dissolved Barium
Anthracene	Total and dissolved Cadmium
Fluorene	Total and dissolved Chromium
Naphthalene	Total and dissolved Copper
Phenanthrene	Total and dissolved Iron
Low Molecular Weight PAHs [1]	Total and dissolved Lead
Benzo(a)anthracene	Total and dissolved Manganese
Benzo(a)pyrene	Total and dissolved Mercury
Dibenzo(a,h)anthracene	Total and dissolved Nickel
Chrysene	Total and dissolved Selenium
Fluoranthene	Total and dissolved Silver
Pyrene	Total and dissolved Strontium
High Molecular Weight PAHs [2]	Total and dissolved Zinc
Total PAHs	NORMs (^{226}Ra and ^{228}Ra)
Production chemicals[3]	
MEG	Scale inhibitors
TEG	Biocide
Oxygen scavenger	H2S scavenger
Total metals	

Parameters	
Total and dissolved Arsenic	Total and dissolved Iron
Total and dissolved Barium	Total and dissolved Lead
Total and dissolved Cadmium	Total and dissolved Manganese
Total and dissolved Chromium	Total and dissolved Mercury
Total and dissolved Copper	Total and dissolved Nickel
Total and dissolved Silver	Total and dissolved Selenium
Total and dissolved Strontium	Total and dissolved Zinc

[1] Low molecular weight PAHs are the sum of concentrations of acenaphthene, acenaphthalene, anthracene, fluorene, 2-methylnaphthalene, naphthalene and phenanthrene.

[2] High molecular weight PAHs are the sum of concentrations of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h) anthracene, fluoranthene and pyrene.

[3] Chemicals are added to the production process and may be present within the PW. Production chemicals are soluble in PW to varying extents and the dissolved fractions may be present within the PW.

1.1.1.2 End-of pipe PW sampling

As described in **Table 1-1**, end of pipe PW sampling to determine dilution factors and the possible extent of the PW mixing zone may be undertaken (based on the decision output from **Figure 1.1**, **Section 1.2.1**).

The following is undertaken:

1. Take sample from end of PW pipe
2. Dispatch a representative sample of PW to test the parameters defined in **Table 1-3**

Once the PW is analysed, a calculation is made to predict whether concentrations of parameters exceed ANZG 2018 guideline values (or otherwise) at the edge of the PW mixing zone, by calculating the likely dilution factor. This may be done on any water quality parameter within **Table 1-3**.

Measures of toxicant concentrations and the expected/measured dilution (D) at the edge of PW mixing zone will be used to calculate the concentration (C) of each water quality parameter (**Table 1-3**) at the edge of the PW Mixing Zone. Either the design dilution will be used in this calculation, or the actual dilution, as measured during the validation part of the baseline monitoring program. The concentration (C) of each water quality parameter at the edge of the PW mixing zone will be determined using:

$$C = (CB) / (D)$$

where:

CB = concentration of the toxicant in the PW prior to discharge
D = the dilution at the edge of the Mixing Zone.

In the event that the end of pipe PW sampling indicates that ANZG 2018 guideline values may be exceeded at the edge of the PW mixing zone, a PW risk assessment **(Section 1.2**) will be applied to determine if any further action is required.

Table 1-3: Parameters measured during PW characterisation (end of pipe sampling)

Parameters	Method	LOR (mg/l)*
Arsenic	ICP-AES	0.002
Cadmium	ICP-AES	0.002

Parameters	Method	LOR (mg/l)*
Chromium	ICP-AES	0.001
Copper	ICP-AES	0.001
Lead	ICP-AES	0.002
Mercury	ICP-AES	0.0005
Nickel	ICP-AES	0.004
Zinc	ICP-AES	0.002

*Based on ANZECC/ARMCANZ (2000) and ANZG (2018) guideline values

1.2 Produced Water Risk Assessment Process

Risk assessments are undertaken in accordance with the MOC process (as per **Section 8.11.2** of the EP) upon the following criteria being triggered:

+ Concentrations of potential contaminants in PW (e.g. Hydrocarbons (O&G, TRH, BTEX); Metals (dissolved and total metals); Inorganics (ammonia, etc.); and Radionuclides) exceed trigger values (e.g. previous characterisation results, ANZG (2018) guideline values – refer to triggers examples in Table 1.4)
+ An ecotoxicity test indicates an increase in safe dilution factors compared to those used to define the PW mixing zone in the EP.
+ An end of pipe PW sampling and associated chemical characterisation results predict that the PW mixing zone has been exceeded.
+ Field sampling indicates that PW mixing zone (459 m from the FPSO during a <30 mg/l PW discharge and 2,182 m from the FPSO during a <70 mg/l PW discharge) to meet ANZECC/ARMCANZ(2000) / ANZG (2018) 99% species protection has not been met.
+ Field sampling indicates sediment quality criteria (where available) from ANZG (2018) is exceeded within or outside the PW mixing zone boundary.

Risk assessments provide assurance that the PW environmental performance outcome is being met and that the acceptable level of impact remains within the PW mixing zone. This risk assessment follows the Santos risk assessment process outlined in Section 5 of the NV Operations EP and in the case of PW considers available information such as:

+ Nature and scale of the PW discharge;
+ PW ecotoxicity testing and dilution factors;
+ PW chemical characterisation testing;
+ PW modelling and/or studies;
+ PW sediment deposition rate analysis;
+ Metal bioavailability analysis; and
+ Particle size distribution analysis.

Risk assessments will investigate the cause of the exceedance. The following may occur as part of the risk assessment:

+ Investigate management / corrective actions to be made on the PW system;
+ PW modelling validation / remodelling;

+ PW impact assessment revisited; and
+ ALARP and acceptability assessments will be reassessed

The following may also occur:

+ Additional PW chemical characterisation analysis
+ Additional PW ecotoxicity testing;
+ Additional PW sediment monitoring; or
+ Additional PW water quality monitoring.

Should the risk assessment show that the PW is not ALARP or acceptable, or is a significant increase in risk then PW is directed inboard until corrective actions to the PW system are made, which assure the PW discharge is ALARP and acceptable.

1.2.1 PW temporary discharge water quality monitoring decision tree

As defined in **Table 1.1** an assessment is undertaken when a temporary discharge (planned or unplanned) occurs, to assess if water quality monitoring is required and can be feasibly undertaken. During a temporary discharge to the marine environment it is acknowledged that there is a level of uncertainty regarding the return to reinjection, as this is dependent on time taken and the ability to resolve the specific failure / operational issue. During a temporary discharge to the marine environment the following process is undertaken within 7 days of the discharge occurring:

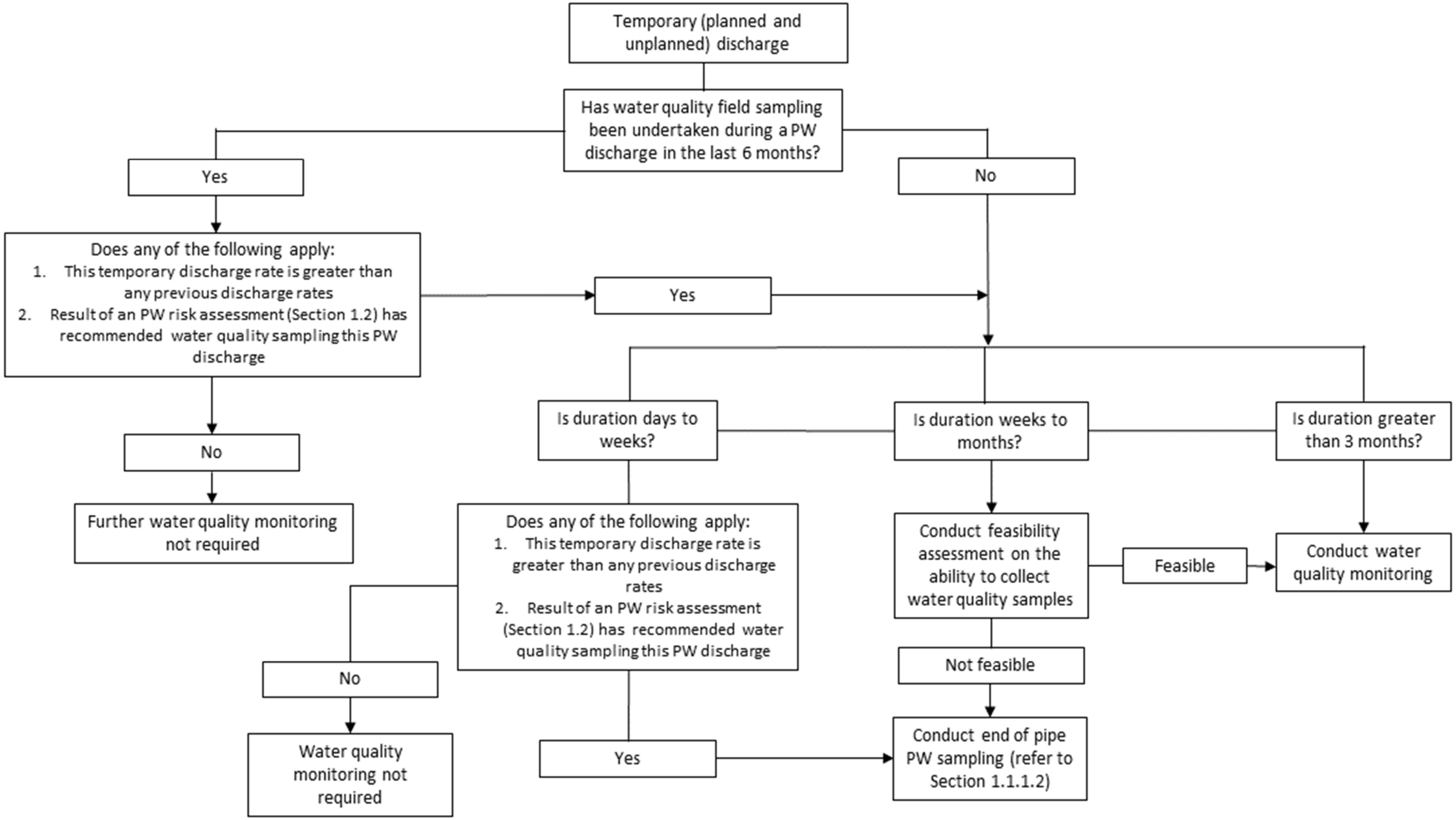

Figure 1-1: Assessment Undertaken During a Temporary Discharge (Planned and Unplanned)

1.3 Adaptive Management Measures

Discharges of PW will be managed through an adaptive management process (**Figure 1-2**). The approach for management of PW follows the framework for environmental management outlined in ANZECC/ARMCANZ (2000) and ANZG (2018). PW is managed to prevent impacts to the marine environment outside the PW mixing zone (described in **Section 6.7.2** of the EP), and will result in a high level of ecological protection, i.e. no difference from natural variability (ANZECC/ARMCANZ, 2000), beyond the PW mixing zone. It also ensures that the PW discharge remains ALARP and acceptable.

Table 1-4 (shown schematically in **Figure 1-2**) describes the approach that is followed should the results of routine PW monitoring (**Table 1-1**) during temporary or permanent discharge have the potential to breach the PW performance outcome (EPO-NV-06) (see **Section 6.7.3** of the EP). Trigger values are applied to capture any uncertainty around the level of impact as soon as possible to ensure that the PW performance outcome is not breached and adaptive managed is applied.

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Table 1-4: Adaptive management measures for Temporary and Permanent Discharge of PW to the Marine Environment

Item	Parameter	Trigger values	Adaptive management response measures
1	OIW	OIW concentration exceeds 30 mg/L based on a 24 hour rolling average	PW will only be discharged to the marine environment achieving a ≤30 mg/L 24 rolling average. If OIW exceeds 30 mg/L, based on a 24 hour rolling average, PW is directed inboard.
		During a High OIW discharge scenario as outlined in Section 6.7.1 and Table 6-19 of the EP, OIW concentration exceeds 70 mg/L based on a 24 hour rolling average.	If OIW exceeds 70 mg/L, based on a 24 hour rolling average, PW is directed inboard.
		Loss of OIW inline analyser signal (e.g. maintenance)	On loss of the OIW inline analyser signal frequency of onboard manual laboratory spectrophotometer measurements for OIW concentration is increased to every 3 hours.
		Trends in OIW concentration between the OIW analyser and the onboard spectrophotometer show readings trending away from each other	Should trends in OIW concentration between the OIW analyser and the onboard spectrophotometer show readings trending away from each other during a permanent discharge scenario the following tiered response occurs: 1. Clean the analyser. If OIW analyser still deviates: 2. Calibrate the analyser in accordance with manufacturers recommendations. PW will only be discharged to the marine environment achieving a ≤30 mg/L 24 hour rolling average.
		NATA accredited laboratory OIW concentration exceeds the manual spectrophotometer laboratory results.	The OIW analyser and the spectrophotometer will be re-calibrated in accordance with manufacturers recommendations.

<table>
<tr><th>Item</th><th>Parameter</th><th>Trigger values</th><th>Adaptive management response measures</th></tr>
<tr><td>2</td><td>Flow rate</td><td>Flow rate is approaching limit of 23,040 m^3 per day.</td><td>PW flow rate is tracked on 3-hourly production averages. If flow rate is trending towards exceeding 23,040 m^3, production is managed so as not to exceed the allowable flow rate.</td></tr>
<tr><td>3</td><td>PW chemical characterisation</td><td>Concentrations of potential contaminants in PW are exceeding ANZG (2018) water quality guideline values or most recent chemical characterisation results.

Parameters tested will include, but are not limited to:
+ Hydrocarbons (O&G, TRH, BTEX);
+ Metals (dissolved and total metals);
+ Inorganics (ammonia, etc.); and
+ Radionuclides.</td><td>An assessment of the PW chemical characterisation results is undertaken by:
1. Comparing against most recent PW chemical characterisation results and
2. Assessing against values (below):
<table>
<tr><th>Component</th><th>Trigger example</th></tr>
<tr><td>Metals</td><td>Assessed against the ANZG (2018) Water Quality Guidelines 95% and 99% species protection guideline values (where available). If no guideline values exist, concentrations will be assessed against background levels*.</td></tr>
<tr><td>Inorganics</td><td>Will be assessed against previous characterisation results. Highlighting and assessing anomalies.</td></tr>
<tr><td>Radionuclides</td><td>Will be assessed against previous characterisation results. Highlighting and assessing anomalies.</td></tr>
<tr><td>Alkylphenols</td><td>Assessed against the ANZG (2018) Water Quality Guidelines 95% and 99% species protection guideline values (where available). If no guideline values exist, concentrations will be assessed against background levels*.</td></tr>
<tr><td>Hydrocarbons</td><td>Assessed against the ANZG (2018) Water Quality Guidelines 95% and 99%</td></tr>
</table></td></tr>
</table>

Item	Parameter	Trigger values	Adaptive management response measures
			species protection guideline values (where available). If no guideline values exist, concentrations will be assessed against background levels*. **background levels will be determined from the baseline sediment monitoring undertaken prior to discharge* If PW is being discharged, then an MOC (as per **Section 8.11.2** of the EP) addressing the factors described in the PW risk assessment (**Section 1.2** this plan) will be undertaken to determine actions required to maintain compliance with PW Performance Outcome and Performance Standards.
		Chemical characterisation from end of pipe PW sampling, indicates that the PW mixing zone[2] to meet ANZECC/ARMCANZ(2000) / ANZG (2018) 99% species protection has not been met	MOC process (as per **Section 8.11.2** of the EP) and PW risk assessment (**Section 1.2**) will be applied if trigger exceeded.
4	Production chemical usage	New chemical use in the process	Assess chemical in accordance with Santos WA Operations Chemical Selection, Evaluation and Approval Procedure (EA-91-II-10001) Chemical only used when use is determined acceptable and ALARP prior to use, in accordance with Santos WA Operations Chemical Selection, Evaluation and Approval Procedure (EA-91-II-10001).
5	PW ecotoxicity	Ecotoxicity testing indicates an increase in safe dilution factors to those used to define the PW mixing zone[2] within the EP	If PW is being discharged, then an MOC (as per **Section 8.11.2** of the EP) addressing the factors described in the PW risk assessment (**Section 1.2** of this Adaptive Management Plan) will be undertaken to determine actions required to maintain compliance with PW Performance Outcome and Performance Standards.

Item	Parameter	Trigger values	Adaptive management response measures
			A Toxicity Identification Evaluation (TIE) may be applied to evaluate the source of the toxicity. Based on the results of the TIE, additional controls such as changing chemical dosing rates and changing chemicals used may be implemented.
6	Water quality field sampling [1]	Field sampling indicates that PW mixing zone[2] to meet ANZECC/ARMCANZ(2000) / ANZG (2018) 99% species protection has not been met	MOC process (as per **Section 8.11.2** of the EP) and PW risk assessment (**Section 1.2**) will be applied if trigger exceeded.
7	Sediment quality field sampling [1]	Field sampling indicates sediment quality criteria (where available) from ANZG (2018) is exceeded within or outside the PW mixing zone boundary	MOC process (as per **Section 8.11.2** of the EP) and PW risk assessment (**Section 1.2**) will be applied if the sediment quality criteria (from ANZG2018, where available) is exceeded within or outside the PW mixing zone. Note: it is a breach of the EPO-NV-07 if sediment quality criteria (from ANZG2018, where available) are exceeded outside the 30 mg/l PW mixing zone.

1 The monitoring program for water quality and sediment quality is described in **Appendix I**

2 PW mixing zone is determined to be 459 m from the FPSO during a <30 mg/l PW discharge and 2,182 m from the FPSO during a <70 mg/l PW discharge

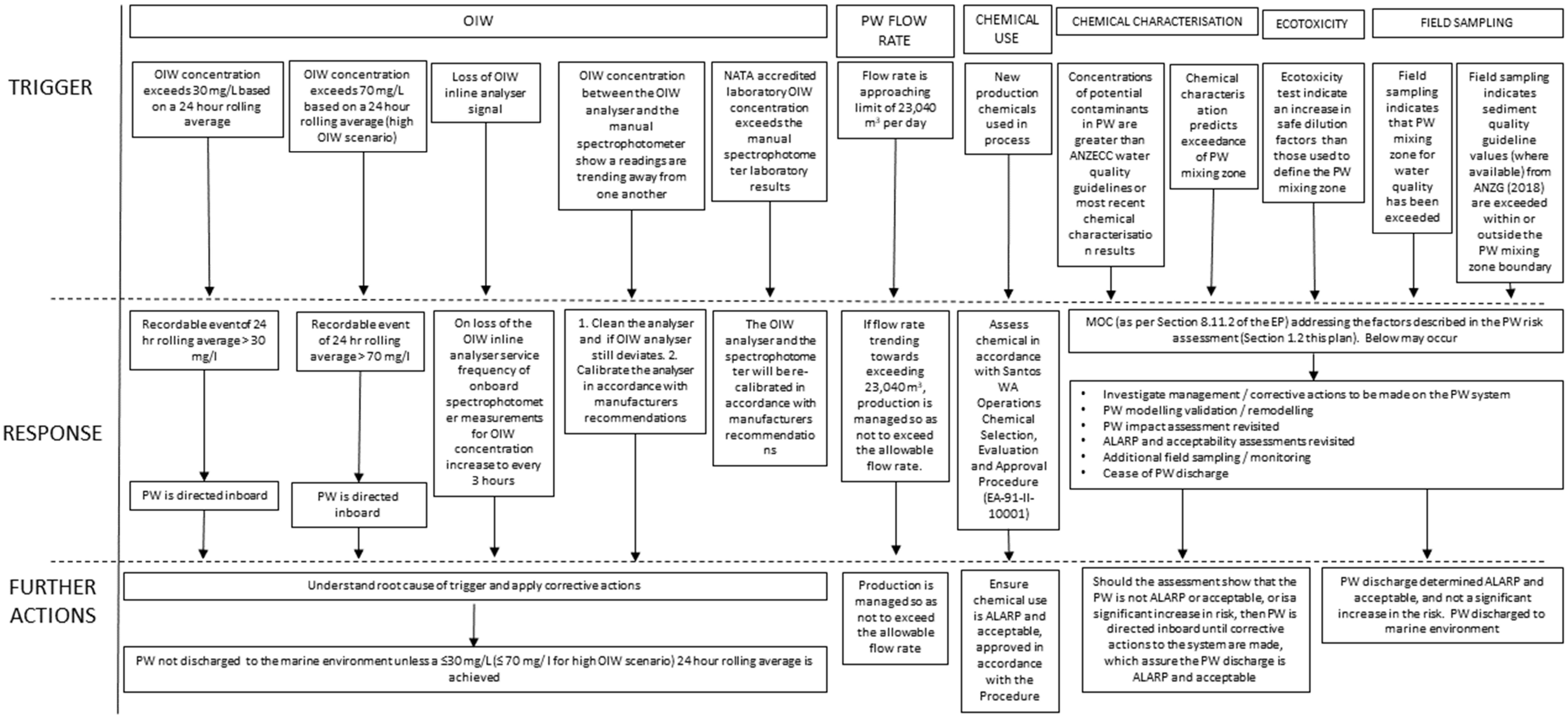

Figure 1-2: Adaptive management measures for Temporary and Permanent Discharge of PW to the Marine Environment

Appendix I. NV PW WATER AND SEDIMENT QUALITY MONITORING AND SAMPLING PLAN

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Indicative Water and Sediment Quality Monitoring and Sampling Plan

1 Objective

Two objectives of this Water and Sediment Quality Monitoring and Sampling Plan (the Plan) are:

1. To provide the monitoring framework for undertaking a baseline monitoring program, within 12 months of EP acceptance and prior to PW discharge to the marine environment, which will aim to establish the background sediment and water quality conditions within the NV field.
2. To provide the framework for an ongoing monitoring program at frequencies and a basis defined within the PW Adaptive Management Plan (Appendix H of the EP) which will determine whether discharge of PW from the FPSO is having a measurable impact on the receiving marine environment (assessed against the baseline).

Measurable impact will be determined by comparing concentrations of contaminants in the receiving environment with ANZG (2018) guideline values for the marine environment. Both water quality and sediment quality guidelines will be used.

Impact will also be determined by adopting a gradient approach to the sampling design so that any exceedances of guideline values or changes in benthic community structure can be attributed to the discharge (and not other natural or anthropogenic factors).

2 Scope

The scope of work required to address the objectives will consist of a water quality monitoring program, a sediment quality monitoring program and a benthic infauna monitoring program[1]. The benthic infauna monitoring has been included as soft sediment habitat is the dominant habitat inside the operational area and within the mixing zone.

3 Timing

A baseline sediment monitoring program is proposed to be completed within 12 months of EP acceptance and prior to PW discharge to the marine environment.

Water quality monitoring will be initiated based on the criteria defined within the PW Adaptive Management Plan (Appendix H of the EP).

Sediment and infauna monitoring would be undertaken at 5 yearly intervals (e.g. once within the life of the EP).

4 Location

The FPSO is located in 340 m water depth at the following location:

[1] It is noted that this Water and Sediment Quality Monitoring and Sampling Plan was developed at time of EP resubmission (July 2020) and may be subject to change prior to implementation as part of continuous improvement.

Latitude (South)	Longitude (East)	Easting (m)	Northing (m)
21°24'12.39"	114°05'17.22"	198096	7630400

The operational area and PW mixing zone do not intercept any marine protected areas, with the closest to the operational area being the Ningaloo Australia Marine Park (AMP) and the Muiron Island Marine Management Area that are located approximately 27 km south and 32 km south east respectively of the operational area.

5 Water Quality Monitoring

5.1 Objective

The objective of this scope is to initially assess the background water quality in the vicinity of the NV FPSO and to establish a baseline for comparison with future discharge of PW.

Once discharge has commenced, water quality monitoring will be undertaken based on the criteria presented in PW Adaptive Management Plan (Appendix H of the EP) to determine whether PW has a measurable impact on water quality in the receiving environment and to also determine the spatial extent of the PW in relation to the mixing zone.

5.2 Sampling Design

The underlying design is to sample at sites located along prevailing current vectors radiating out from the FPSO. This provides an approach to identify changes in water and sediment quality due to PW discharges, with increasing distance from the facility. The gradient design will provide baseline and post commissioning data for comparison.

The approach meets the ANZECC/ARMCANZ (2000) and ANZG (2018) recommendations to incorporate sublethal responses of organisms (e.g. WET testing) with probable disturbance gradients for monitoring water and sediment quality.

The water quality sampling locations will be determined by the current direction at the time of sampling. Sediment sample sites will be determined based on the modelling of prevailing currents.

5.3 Survey Locations

For water quality monitoring, sampling vectors on the maps will be nominally based on long term prevailing currents and plume modelling. Once the FPSO is operational, water sampling undertaken during operations will rely on dye injection into the PW stream to align with the plume direction for the collection of samples. The dye will be tracked in the receiving waters using a suitable method, e.g. drogue tracking, UAV or fluorometer. Water quality monitoring will then be undertaken in the plume as evidenced by the presence and concentration of dye in the water column.

Water samples will typically be collected at 16 sites around the FPSO, to determine the extent of nearfield mixing. Samples will be collected along transects parallel and perpendicular to the prevailing current at a depth of approximately -1 m below sea level (BSL) and distances of 50 m, 100 m, 500 m and 1000 m , and 2,500 m away from the FPSO, as shown in **Figure 5-1**. The sampling location at 2,500 m will act as a reference for a high OIW discharge scenario. Additional samples may be collected closer to the discharge point (from the FPSO) depending on access and between sampling points shown in **Figure 5-1**.

Samples at 100, 500 m and 1000 m are selected to monitor any effect of the PW discharge within the modelled plume extents (refer to Section 6.7. of the EP). The following extents are determined:

- Samples collected out to 1000 m will be used to determine if there is any impact beyond the (PW mixing zone) during a ≤30 mg/l PW discharge.

+ Sampling will occur out to 2.5 km from the FPS) to determine if there is any impact beyond the 70 mg/l PW mixing zone

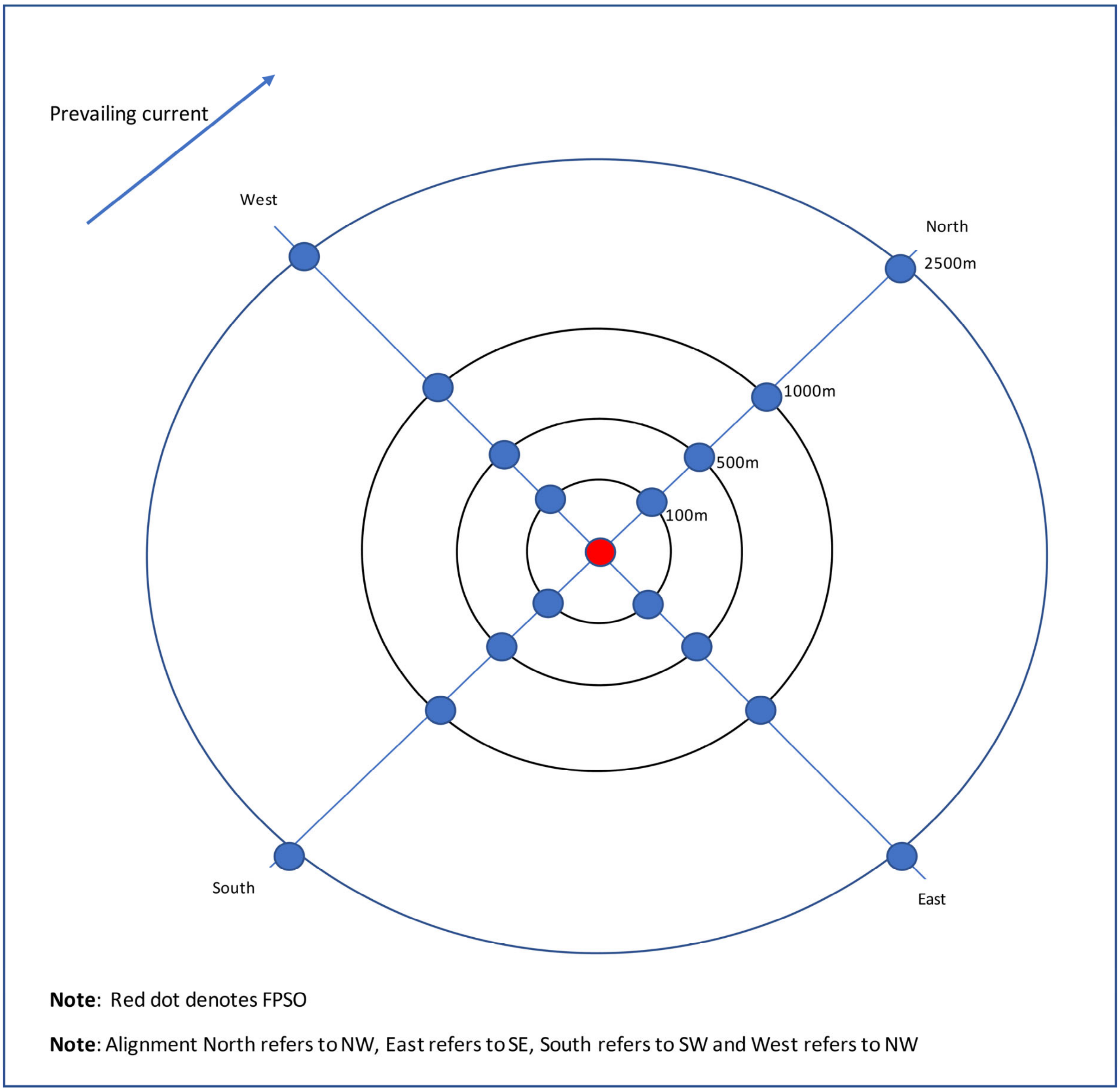

Figure 5-1: Indicative water sampling design

5.4 Verification of Plume

Once operational, a dye tracer study will be implemented to understand the plume movement for water sampling and to assist in verification of the plume modelling using Rhodamine or another suitable dye. Rhodamine is a conservative tracer and concentrations in the water column are regularly used for comparing modelled estimates of dilution with in-situ measurements.

5.5 Sampling Method

5.5.1 Water Quality Profiles

Vertical profiles will be taken at a range of water depths through the water column, using a suitable profiler, that is capable of measuring conductivity, temperature and depth as a minimum (e.g. Seabird Electronics SBE19 Seacat profiler). In addition, water samples collected sub-surface will also be taken.

Measurements should be recorded at 4Hz (every 0.25 seconds) from 0 to approximately 35m water depth and at each of the water quality sampling locations. Two depth profiles are recorded at each sampling site to ensure high quality data capture. The water quality profiler should be lowered / raised at a speed of approximately 1 metre per second. At each location, the profiler should be lowered to approximately -1 m BSL and allowed to equilibrate for 30 seconds before profiling begins to ensure that all parameters have stabilised.

5.5.2 Water Quality Sampling

At each sampling location, a surface sample will be collected using either a 5 L Niskin water sampler or a 10 L (hydrocarbon safe) plastic bucket. The samples will be collected from approximately -1.0 m BSL to prevent contamination from any floating detritus for surface locations or from approximately -5 m BSL for mid-water samples. However, this should be validated during the survey based on results from the plume verification and CTD (conductivity, temperature, depth) casts to identify the location of the PW plume in the profile. Samples will be taken on the upwind side of the survey vessel, to minimise the risk of contamination from hydrocarbons from the vessel. Samples may need to be collected from the facility if the sites are in a vessel exclusion zone unless express permission is granted by the OIM.

Further details regarding sample collection, sample processing and quality control should be detailed in a sampling and analysis plan that is prepared prior to undertaking the monitoring program. Sampling collection, processing, transportation, storage, preservation and labelling will be conducted in accordance with the ANZG (2018) guideline.

Samples will be sent to NATA accredited laboratories capable of achieving Limits of Reporting to meet the ANZG (2018) PQLs for the proposed analyte listed below.

Table 5-1: Proposed Test Parameters and Recommended PQLs

Analyte	Target Practical Quantification Limit	Method
Ammonium (NH4-N)	<5 µg.N/L (0.005 mg/L)	APHA 4500BFG
Nitrite (NO2-N)	<2 µg.N/L (0.002 mg/L)	APHA 4500BFG
Nitrate (NO3-N)	<2 µg.N/L (0.002 mg/L)	APHA 4500BFG
Total Nitrogen (TN-Persulphate)	<50 µg.N/L (0.050 mg/L)	APHA 4500BFG
Orthophosphate (PO4-P)	<2 µg.N/L (0.002 mg/L)	APHA 4500BFG
Total Phosphorus (TP-Persulphate)	<5 µg.N/L (0.002 mg/L)	APHA 4500BFG
Total Dissolved Solids (TDS)	1 mg/L	APHA 4500BFG
Total Suspended Solids (TSS)	2 mg/L	APHA 4500BFG
Biochemical Oxygen Demand (BOD)	2 mg/L	APHA 4500BFG
Chemical Oxygen Demand (COD)	5 mg/L	APHA 4500BFG
Total Petroleum Hydrocarbon (TPH) (C_6-C_{36})	25/50/100/100 µg/L	USEPA 8260 / P&T GCMS

Benzene, Toluene, Ethyl Benzene and Xylenes (BTEX)	1 µg/L	USEPA 8260 / P&T GCMS
Poly-Aromatic Hydrocarbons (PAH)	1 µg/L	USEPA 3500C / 8270D GCMS
Phenols	1 µg/L	USEPA 3500C / 8270D GCMS
Aliphatic Speciation Aliphatic Hydrocarbons (C_{16}-C_{35})	100 µg/L	USEPA 3500C / 8270D GCMS
Cations (Ca, Mg, K, Na)	1 mg/L	USEPA 200.8 ICP/MS
Radium-226 Radium-228	Bq/L 0.1 Bq/L	Gamma Spectrometry Gamma Spectrometry
Trace Metals – 15 dissolved		
Arsenic	0.5 µg/L	USEPA 200.8 ICP/MS
Barium	1 µg/L	
Boron	100 µg/L	
Cadmium	0.2 µg/L	
Chromium	1 µg/L	
Cobalt	0.1 µg/L	
Cooper	0.2 µg/L	
Iron	5 µg/L	
Manganese	0.6 µg/L	
Mercury	0.1 µg/L	
Nickel	0.5 µg/L	
Lead	0.2 µg/L	
Silver	0.1 µg/L	
Strontium	10 µg/L	
Zinc	5 µg/L	

5.5.3 Data Analysis

Results from the laboratory analysis will be presented in summary tables with comparisons to ANZECC 99% and 95% species protection guidelines values. Analysis of data will also include a description of physico-chemical water quality characteristics, including presence and concentration of hydrocarbons, heavy metals and background.

Following discharge of PW, the key objective is to assess the presence of a gradient from the discharge point outwards towards any of the cardinal sampling points or targeted sampling points. A range of statistical tests are available for determining the presence of gradient effects including:

+ Linear regressions to assess for a relationship between distance from discharge and concentrations of selected contaminants
+ Multivariate statistical analysis using Distance Based Linear Model (DistLM) to determine if there is a gradient impact in the suite of water quality parameters tested (where present above the limit of reporting).

6 Sediment Monitoring Program

6.1 Objective

The objective of this scope is to assess baseline sediment quality within the vicinity of the NV FPSO. If PW is discharged overboard, targeted field based sampling and monitoring is proposed to assess the potential long term accumulation of contaminants within the production field from discharge of PW.

6.2 Sampling Design

The underlying design is to sample at sites located along prevailing current vectors radiating out from the FPSO. This provides an approach to identify changes in water and sediment quality due to PW discharges, with increasing distance from the facility. The gradient design will provide baseline and post commissioning data for comparison.

Sediment sample sites will be determined based on the modelling of prevailing currents.

6.3 Survey Locations

The sampling design for the sampling was developed to measure the sediment quality around the FPSO, from different directions and distances (**Figure 6-1**). A total of 48 samples will be collected from 16 sites, with each site consisting of three replicates adjusted for suitable clearances from subsea infrastructure.

The sampling sites will be located at twelve impact sites in a two layer ring formation around the FPSO at increasing intervals at 100 m, 500 m 1000 m and 2500 m north-east, south-east, south-west and north-west. Additional samples may be collected closer to the discharge point (from the FPSO) depending on access and between sampling points shown in **Figure 6-1.**

Sampling locations should be confirmed using a positioning system of high accuracy.

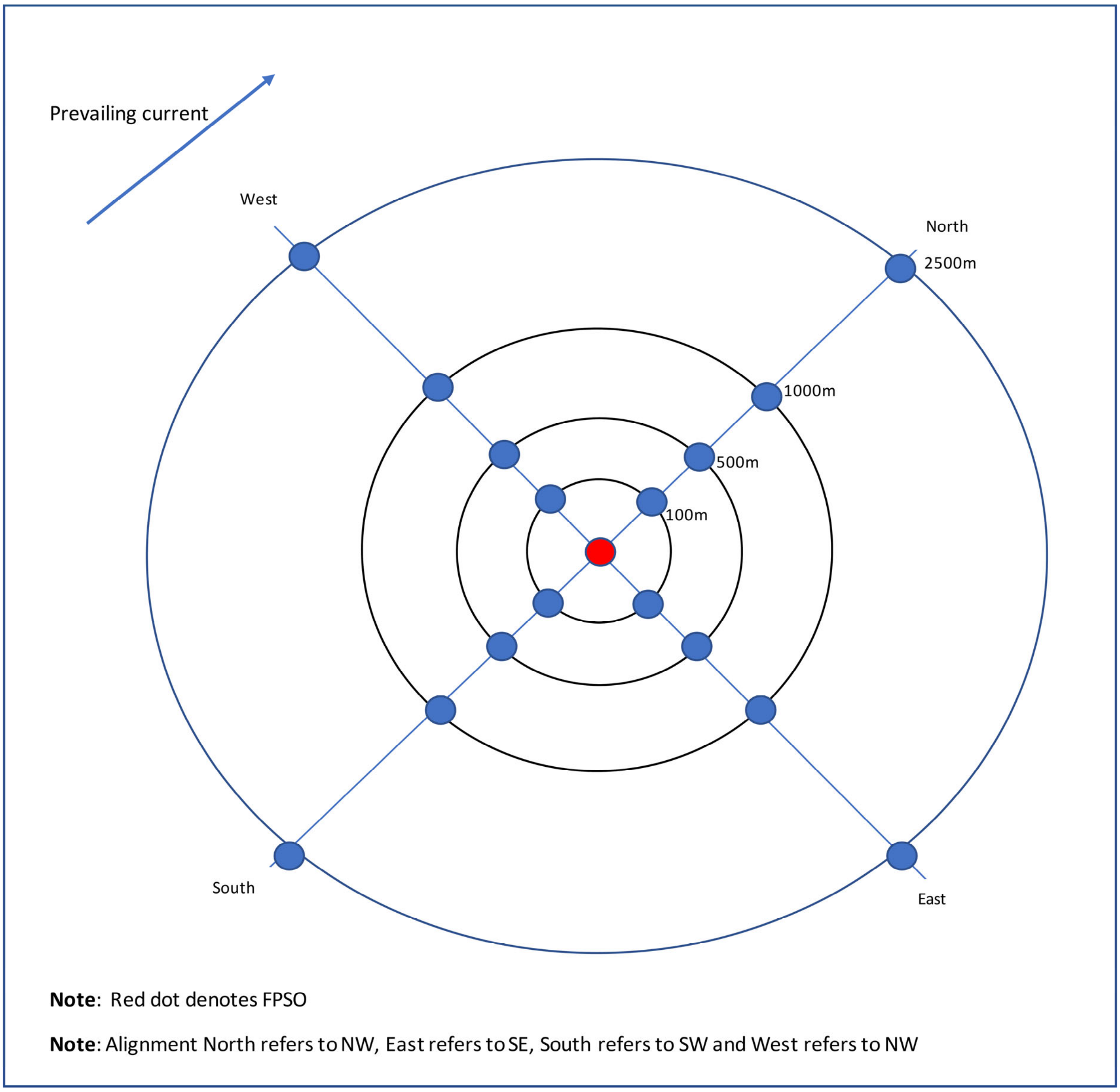

Figure 6-1 Sampling design showing position of sites relative to FPSO

6.4 Sampling Method

Sediment samples will be collected either using vessel based methods that involve operation of a grab/corer or remote methods via operation of an ROV. The method will depend on the water depth, locations of sampling with respect to the facility and other tasks in the survey. The selection of the method should also consider the ability to safely deploy and retrieve the samples without impacting on existing FPSO infrastructure on the seabed, e.g. pipelines...

6.4.1 Box Corer

Box corer samples will be collected using a corer deployed with the deck crane and winch ensuring there is sufficient cable for the water depths being sampled. The box corer will be operated according to appropriate lifting plans and deployment and recovery procedures.

6.4.2 Alternative Methodology - Push Cores

Alternatively, samples can be collected using an Elkin push corer (or similar) operated by ROV under the guidance of qualified environmental scientists/engineers. The proposed method of sampling provides the ability to collect sediment samples close to existing subsea equipment with a high degree of accuracy. The main disadvantage with the ROV method is the limited volume of samples that can be collected at each time.

6.4.3 Sediment Quality Sampling

The following parameters will be tested within the sediments (**Table 6.1**).

Table 6-1: Proposed Test Parameters and Recommended LoRs

Analyte	Method	Limit of Reporting*
Moisture content	Gravimetric	0.1%
Particle Size Distribution	Sieve and Sedigraph	0.01
Total Organic Carbon	-	0.02%
Arsenic	USEPA 3050/200.7 ICP/AES	0.4
Barium	USEPA 3050/200.7 ICP/AES	0.1
Boron	USEPA 3050/200.7 ICP/AES	5
Cadmium	USEPA 3050/200.7 ICP/AES	0.1
Chromium	USEPA 3050/200.7 ICP/AES	0.1
Cobalt	USEPA 3050/200.7 ICP/AES	0.5
Copper	USEPA 3050/200.7 ICP/AES	0.1
Iron	USEPA 3050/200.7 ICP/AES	5
Lead	USEPA 3050/200.7 ICP/AES	0.5
Magnesium	USEPA 3050/200.7 ICP/AES	5
Manganese	USEPA 3050/200.7 ICP/AES	0.5
Nickel	USEPA 3050/200.7 ICP/AES	0.1
Strontium	USEPA 3050/200.7 ICP/AES	1.0
Zinc	USEPA 3050/200.7 ICP/AES	0.5
Mercury	USEPA 3050/7471A CVAAS	0.01
BTEX	USEPA 8260/P&T GCMS	0.2 – 1.2
TPH (C6-C9)	USEPA 8260/P&T GCMS	10
TPH (C10-C36)	USEPA 3550B/8015B GC/FID	10-50
PAH	USEPA 3550B/8270 GCMS	5-10, total PAH 100

*ANZG (2018) guideline values for sediment quality

6.4.4 Data Analysis

All concentrations to be compared with sediment quality criteria (where available) from ANZG (2018) https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants.

Table 6-2: Proposed Test Parameters and Recommended Levels of Reporting

	Toxicant	DGV (Default Guideline Value)	DGV - High
Metals (mg/kg, dry wt)	Cadmium	1.5	10
	Chromium	80	370
	Copper	65	270
	Lead	50	220
	Mercury	0.15	1.0
	Nickel	21	52
	Zinc	200	410
Metalloids (mg/kg)	Arsenic	20	70
Organics (µg/kg dry weight,)*	Total PAH	10,000	50,000
Organics (mg/kg dry weight)*	TPH	280	550

* Normalised to 1% OC within the limits of 0.2 to 10%

Where possible, the data will be tested statistically using ANOVA (Analysis of Variance) to determine if there were differences in the sediment quality results of individual variables between distance and direction.

7 Benthic Infauna Monitoring

7.1 Objective

The objective of this part of the Baseline and Monitoring Plan is to assess the abundance and diversity of infauna at selected locations proximal to the FPSO. The study aims to:

+ Determine the current diversity and abundance of benthic infauna to provide a baseline prior to discharge of PW and to assess impact to benthic infauna following discharges of PW from the NV FPSO

7.2 Sampling Design

Infauna sampling should be undertaken at the same sites as those targeted for sediment sampling so that representative samples are collected simultaneously.

All sampling sites should be located in areas of soft seabed and taken along a similar depth contour (approximately 340 m), or as close to this depth as possible.

7.3 Sampling Procedure

Infauna samples will be collected using apparatus deployed as part of the sediment monitoring program. At each survey location, three replicate sediment samples from each location should be collected.

Once on board the vessel, the replicate samples should be sieved through a 1mm mesh sieve and then transferred into suitable sample containers that are labelled with sampling details. The sieve shall be examined after removal of the sample, with any animals trapped in the mesh added to the sample. All material in the containers should be covered in a solution of 10% formalin and seawater. The formalin solution should be buffered with borax to ensure that calcium carbonate structures (e.g. molluscs) in the samples remained intact.

The sieve is then rinsed with ionised water to avoid any cross-contamination. Sample containers are to be labelled internally and externally with project details, time, date, site, location and replicate sample number and placed in a sealed and labelled poly-drum. Five replicate samples are to be collected per location. Global Positioning System (GPS) coordinates and times were recorded at the start and finish of sampling at each sub-site.

Decontaminating all sampling equipment, including sieves, grab sampler, bowls etc., between sampling locations via a decontamination procedure involving a wash with ambient sea water and a laboratory grade detergent, and successive rinsing with deionised water; or by a similarly acceptable method.

7.4 Laboratory Procedure

Upon arrival at the laboratory, the infauna samples are washed in clean water and rinsed through a 1 mm mesh sieve. Bengal Rose dye can be added to the sample to assist with sorting.

Animals are removed from the sediment using a binocular microscope and forceps and stored according to their higher taxonomic group with the project details and sample information.

Samples are to be identified at least to family level and to species level where possible. Identification to family level has been established as adequate for the detection of impacts on infauna communities (Warwick 1988).

7.5 Data Analysis

Taxa abundance, richness and diversity will be calculated for the infauna data. A brief definition of each of these is provided below:

Taxa abundance: Relates to how common or rare taxa are relative to other taxa in a defined location or community.

Taxa richness: A measure related to the total number of different taxa present within a sample.

Taxa diversity: Taxa diversity accounts for the number of taxa and the evenness of taxa giving a measure of the biodiversity and complexity of a population. Taxa diversity consists of two components, taxa richness and taxa evenness. Taxa richness is a simple count of taxa, whereas taxa evenness quantifies how equal the abundances of the taxa are.

Taxa diversity was calculated using the Shannon Weiner diversity index as follows;

$H = \Sigma - (Pi * \ln Pi)$

$i = 1$

Where:

H = the Shannon diversity index

Pi = fraction of the entire population made up of taxa i

Σ = sum from taxa 1 to taxa S (number of taxa encountered)

Both univariate statistical analyses (using Statistica Version 7 or equivalent) and multivariate analyses (using PRIMER) will be undertaken to compare differences between sites.