WA-28-P Drilling Environment Plan Summary

Exploration Division

March 2019

Revision 0

Table of Contents

1. INTRODUCTION 6
1.1 Defining the Activity 6
2. LOCATION OF THE ACTIVITY 7
3. DESCRIPTION OF THE ACTIVITY 8
3.1 Purpose of the Activity 8
3.2 Timing of the Activities 8
3.3 Project Vessels 9
3.3.1 MODU 9
3.3.2 Installation Support Vessels 10
3.3.3 Support Vessels 10
3.3.4 Refuelling 10
3.4 Other Support 10
3.4.1 Remotely Operated Vehicles 10
3.4.2 Helicopters 11
3.5 MODU and Vessel Activities 11
3.6 Drilling Activities 12
3.6.1 Cement Unit Test 12
3.6.2 Top Hole Section Drilling 12
3.6.3 Blowout Preventer and Marine Riser Installation 13
3.6.4 Bottom Hole Section Drilling 13
3.6.5 Formation Evaluation 14
3.6.6 Well Clean-up 14
3.6.7 Drill Stem Testing 14
3.6.8 Well Abandonment 15
3.7 Project Fluids 15
3.7.1 Assessment of Project Fluids 15
3.7.2 Drilling Fluid System 16
3.7.3 Drill Cuttings 17
3.8 Contingent Activities 17
3.8.1 Respud 18
3.8.2 Sidetrack 18
3.8.3 Well Suspension 18
3.8.4 Wellhead Assembly Left In-situ 18
3.8.5 Sediment Relocation 18
3.8.6 Venting 18
3.8.7 Emergency Disconnect Sequence 18
4. DESCRIPTION OF THE RECEIVING ENVIRONMENT 20
4.1 Regional Setting 20
4.2 Physical Environment 21
4.3 Biological environment 22

4.3.1 Benthic communities 22
4.3.2 Plankton 23
4.3.3 Species 23
4.4 Socio-Economic and Cultural 30
4.4.1 Heritage 30
4.4.2 Commonwealth and State Fisheries 31
4.4.3 Tourism 32
4.4.4 Shipping activity 32
4.4.5 Oil and gas activity 33
4.4.6 Defence 34
4.5 Values and Sensitivities 34
5. ENVIRONMENTAL IMPACTS AND RISKS 38
5.1 Risk and Impact Identification and Evaluation 38
5.1.1 Establish the Context 39
5.1.2 Impact and Risk Identification 39
5.1.3 Risk Analysis 39
5.1.3.1 Decision Support Framework 39
5.1.3.2 Identification of Control Measures 40
5.1.3.3 Risk Rating Process 40
5.1.4 Impact and Risk evaluation 42
5.1.4.1 Demonstration of ALARP 42
5.1.4.2 Demonstration of Acceptability 43
5.2 Hydrocarbon Spill Risk Assessment Methodology 43
5.2.1 ZoC and Hydrocarbon Contact Thresholds 43
5.2.2 Surface Hydrocarbon Threshold Concentrations 44
5.2.3 Dissolved Aromatic Hydrocarbon Threshold Concentrations 45
5.2.4 Entrained Hydrocarbon Threshold Concentrations 46
5.2.5 Accumulated Hydrocarbon Threshold Concentrations 47
6. ENVIRONMENTAL RISK AND IMPACTS SUMMARY 48
7. ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE 53
7.1 Environment Plan Revisions and Management of Change 53
8. OIL POLLUTION EMERGENCY RESPONSE ARRANGEMENTS 55
8.1 Woodside Oil Pollution Emergency Arrangements (Australia) 55
8.2 WA-28-P Drilling Oil Pollution First Strike Plan 55
8.3 Oil Spill Preparedness and Response Mitigation Assessment 56
9. CONSULTATION 58
9.1 Ongoing Consultation 59
9.2 Non-Routine Events 59
10. TITLEHOLDER NOMINATED LIAISON PERSON 60
11. ABBREVIATIONS 61
12. REFERENCES 64

APPENDIX A: ENVIRONMENTAL IMPACTS AND RISKS 71

APPENDIX B: CONTROL MITIGATION MEASURES FOR POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH SPILL RESPONSE ACTIVITIES 161

12.1 Identification of impacts and risks from implementing response strategies 162
12.2 Analysis of impacts and risks from implementing response strategies........................... 163
12.3 Evaluation of impacts and risks from implementing response strategies 163
12.4 Treatment of impacts and risks from implementing response strategies........................ 165

APPENDIX C: SUMMARY OF STAKEHOLDER FEEDBACK AND WOODSIDE'S RESPONSE 167

List of Tables

Table 2-1: Approximate location details for the Petroleum Activities Program 7
Table 3-1: Current MODU specifications ranges for Ocean Apex and Ensco MS-1......................... 9
Table 4-1 Threatened and migratory marine species under the EPBC Act potentially occurring with the PAA or within the wider ZoC 23
Table 4-2: Summary of established and proposed Marine Protected Areas (MPAs) and other sensitive locations in the PAA and wider ZoC 36
Table 5-1: Woodside Risk Matrix (environment and social and cultural) consequence descriptions 41
Table 5-2: Woodside risk matrix likelihood levels 41
Table 5-3: Summary of Woodside's criteria for ALARP demonstration... 42
Table 5-4: Summary of Woodside's criteria for Acceptability.. 43
Table 5-5 Summary of thresholds applied to the quantitative hydrocarbon spill modelling results . 44
Table 5-6: The Bonn Agreement oil appearance code 45
Table 5-7: Comparison of GDA 01/02 Composite, GDA Condensate and Browse Condensate characteristics.. 45
Table 5-8: Summary of total recoverable hydrocarbons NOECs for key life-histories of different biota based on toxicity tests for WAF of Browse Basin condensate 46
Table 6-1: Environmental Risk and Impacts Register Summary... 49
Table 9-1: Relevant Stakeholder Identified for the Petroleum Activities Program 58
Table 12-1: Noise level thresholds for cetaceans, marine turtles and whale sharks, and expected distance from the source where noise levels will dissipate to below the relevant thresholds 78
Table 12-2: Threshold for seismic airguns (impulsive) exposure to fish and sea turtles (adopted from Popper et al. 2014) 80
Table 12-3: Estimated discharges of cuttings and volumes of drilling fluids used for the Petroleum Activities Program.. 89
Table 12-4: Relief well drill times.. 104
Table 12-5: Summary of modelled credible scenario – well blowout 105
Table 12-6: Egret-3 Medium Crude characteristics 105
Table 12-7: Range of assumed inputs and range of calculated outputs, by OILMAP-Deep model for the surface/subsea well loss of containment (crude).. 108
Table 12-8: GDA 01/02 Composite Condensate and GDA 01 Condensate characteristics 110
Table 12-9: Range of assumed inputs and range of calculated outputs, by OILMAP-Deep model for the surface/subsea well loss of containment (GDA 01 condensate).. 112
Table 12-10: Accumulated shoreline concentration (crude)... 113
Table 12-11: Accumulated shoreline concentration (condensate) 114
Table 12-12: Zone of Consequence – Key Receptor Locations and Sensitivities with the Summary Hydrocarbon Spill Contact for a 56 day subsea blowout of crude and condensate...................... 115
Table 12-13: Summary of credible hydrocarbon spill scenario as a result of vessel collision....... 136

Table 12-14: Characteristics of the marine diesel used in the modelling 137
Table 12-15: Potential receptors contacted by entrained diesel <500 ppb.... 138
Table 12-16: Zone of Consequence – Key Receptor Locations and Sensitivities with the Summary Hydrocarbon Spill Contact for an instantaneous release of marine diesel 140
Table 12-17: Characteristics of the non-water based mud base oil 146
Table 12-18: Analysis of risks and impacts 163

List of Figures

Figure 2-1: Location of the Petroleum Activities Program 7
Figure 4-1: Vessel density map for the PAA from 2016, derived from AMSA satellite tracking system data 33
Figure 4-2: Established and proposed Commonwealth and State Marine Protected Areas in relation to the PAA 35
Figure 5-1: Key steps in Woodside's Risk Management Framework 38
Figure 5-2: Woodside risk matrix: risk level 42
Figure 12-1: Credible oil spill scenario identification process 104
Figure 12-2: Proportional mass balance plot representing the weathering of 50 m^3 from a surface spill of Egret-3 medium crude.... 107
Figure 12-3: Gross mass balance plot representing the weathering of Egret-3 Medium Crude for a 56-day surface/subsurface release at Achernar-1. 108
Figure 12-4: Proportional mass balance plot representing the weathering of 50 m^3 from a surface spill of GDA 01/02 composite condensate.... 111
Figure 12-5: Proportional mass balance plot representing the weathering of 50 m^3 from a surface spill of GDA 01 condensate.... 111
Figure 12-6: Proportional mass balance plot representing weathering of a surface spill of marine diesel as a one-off release (50 m^3 over 1 hr) and subject to variable wind at 27 °C water temperature and 25 °C air temperature. 138

1. INTRODUCTION

Woodside Energy Ltd (Woodside), as Titleholder under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth) (referred to as the Environment Regulations), proposes to undertake drilling of up to six wells (three exploration and three appraisal wells), including the Achernar exploration well. All drilling activities will take place within Permit Area WA-28-P, hereafter, referred to as the Petroleum Activities Program. The wells are being drilled to explore for potentially commercial hydrocarbon resources and as a commitment under Exploration Permit WA-28-P requirements, issued under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) (OPGGS Act).

This Environment Plan summary has been prepared as part of the requirements under the Environment Regulations, as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.1 Defining the Activity

The Petroleum Activities Program to be undertaken comprises exploration and appraisal drilling. These activities are defined as petroleum activities within Regulation 4 of the Environment Regulations and as such an EP is required.

2. LOCATION OF THE ACTIVITY

The proposed Petroleum Activities Area (PAA) is located in Permit Area WA-28-P, in Commonwealth waters on the continental slope approximately 127 km north-west of Dampier (**Figure 2-1**).The closest landfall to the PAA are islands of the Dampier Archipelago, which are approximately 85 km south-east at the closest point. Water depths within the PAA range between 100 m to 129 m.

Approximate location details for the Petroleum Activities Program are provided in **Table 2-1**.

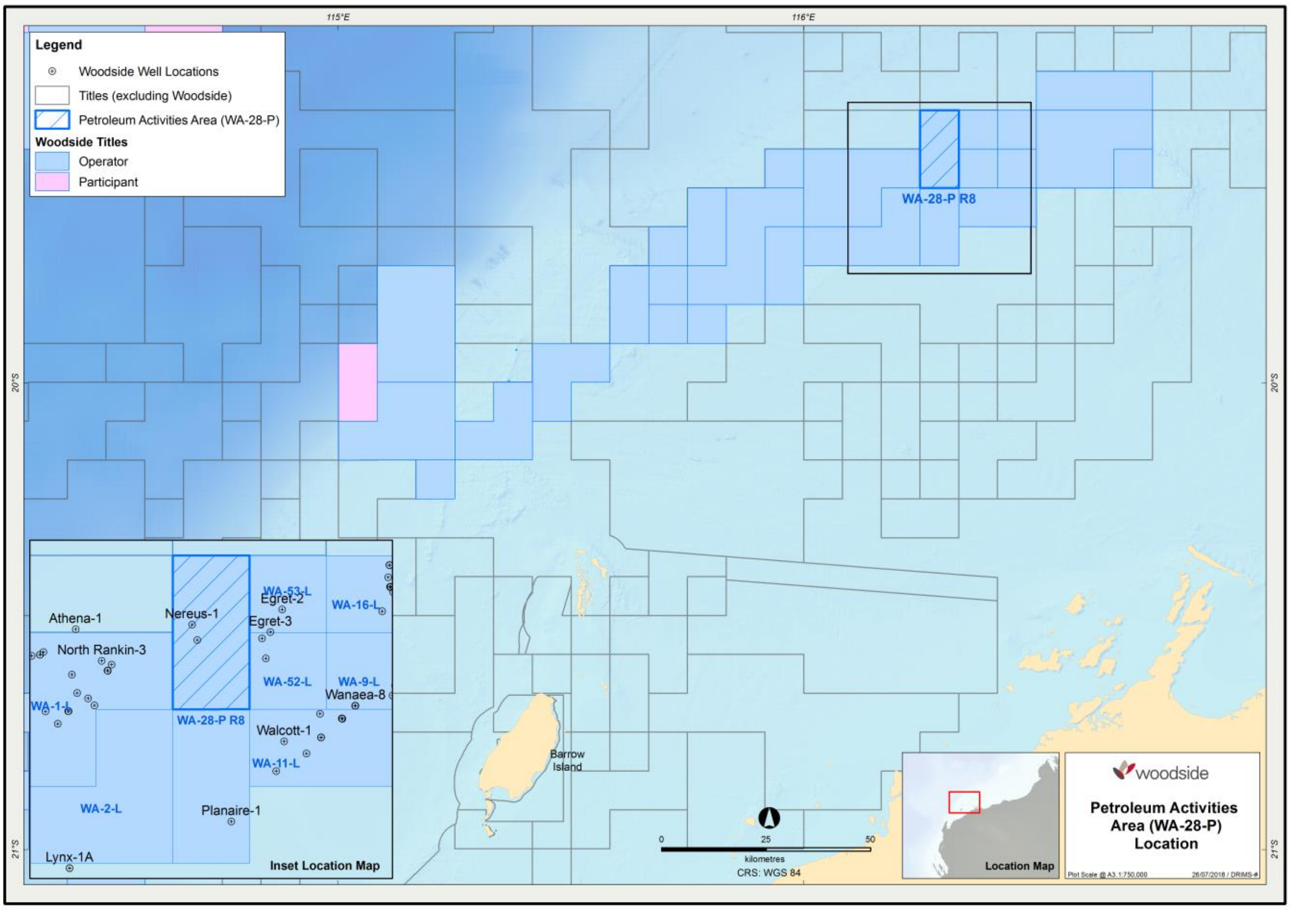

Figure 2-1: Location of the Petroleum Activities Program

Table 2-1: Approximate location details for the Petroleum Activities Program

Activity	Water Depth (Approx. m Lowest Astronomical Tide)	Latitude	Longitude	Permit Area
Achernar exploration well	124 m	19º28’04.723ºS	116º18’18.177ºE	WA-28-P
Exploration wells (2 and 3)	100 m to 129 m	To be determined (but within the PAA)		WA-28-P
Appraisal wells (1 to 3)	100 m to 129 m	To be determined (but within the PAA)		WA-28-P

The spatial boundary of the Petroleum Activities Program has been described and assessed using two "areas", the PAA and the Operational Area (discussed below).

The PAA defines the spatial boundary within which the Petroleum Activities Program will take place. The PAA comprises the northern half of Permit Area WA-28-P. As the locations of five of the six exploration and appraisal wells within the PAA are unconfirmed at the time of EP submission to NOPSEMA, a conservative approach in assessing risks has been employed for this EP. This approach considered the existing environment of the entire PAA (along with the environment potentially impacted by the credible hydrocarbon spill scenarios) to provide context for the risk assessment. This approach facilitates the assessment of environmental risks and impacts for all potential well locations to allow for the inherent uncertainty for well locations that are yet to be determined.

The Operational Area encompasses a radius of 4000 m from the well centre, for each of the six proposed exploration/appraisal wells. As a result, there will be up to six Operational Areas for the Petroleum Activities Program however only one will be effective at a given point in time (no concurrent drilling).

The 4000 m Operational Area allows for MODU mooring operations, including the possible installation of pre-laid moorings and vessel related petroleum activities[1]. The Operational Area for drilling activities includes a 500 m petroleum safety zone around the MODU to manage vessel movements. The 500 m petroleum safety zone is under the control of the MODU Person in Charge (PIC) and excludes other vessels from this area. A 500 m safety zone will also exist around the ISV during CAN installation, should this be undertaken, and will be under the control of the vessel captain.

3. DESCRIPTION OF THE ACTIVITY

3.1 Purpose of the Activity

Woodside proposes to undertake the drilling of up to three exploration wells and up to three appraisal wells within the PAA. Detailed planning and scheduling of the Achernar exploration well is currently being undertaken, with the remaining exploration/appraisal wells to be planned pending outcomes of Achernar or as required under Permit Area requirements issued under the OPGGS Act (Cth).

3.2 Timing of the Activities

The proposed Petroleum Activities Program is scheduled to commence in the second quarter of 2019 with drilling of the Achernar exploration well. After the Achernar exploration well, there are currently no other exploration/appraisal wells scheduled; however, this EP is being written to cover other future drilling in the PAA. This is to allow for subsequent exploration/appraisal wells pending the outcome of the Achernar exploration well and other commitments. Drilling of the exploration and appraisal wells is expected to take approximately 20–40 days (including mobilisation and demobilisation) per well, and up to 120 days with contingency, to complete, excluding well testing activities. Duration of well testing is expected to be approximately 25 days per well.

There are no planned concurrent drilling activities under the EP.

Timing and duration of these activities is subject to change due to project schedule requirements, MODU/vessel availability, unforeseen circumstances and weather.

This EP has risk assessed drilling activities throughout the year (all seasons), to provide operational flexibility for requirements and schedule changes, as well as vessel/MODU availability.

[1] Vessels supporting the Petroleum Activities Program operating outside of the Operational Area (e.g. transiting to and from port) are subject to all applicable maritime regulations and other requirements which are not managed under this EP.

3.3 Project Vessels

Several vessel types will be required to complete the activities associated with the Petroleum Activities Program. These are discussed in further detail in the following sections and will include:

- semi-submersible moored MODU
- ISV for activities such as CAN installation (if used)
- support vessels, required for activities such as to run and set anchors and operate on standby to support the MODU during operations.

Description and assessment of support vessel environmental impacts and risks, credible spill scenarios and environmental sensitivities for the activities within the scope of this EP. Some support vessels may be required on an ad-hoc basis to support periods of high activity and will be subject to the above processes.

3.3.1 MODU

The Petroleum Activities Program will be drilled by a MODU. This is expected to be a semi-submersible MODU that is moored (e.g. the *Ocean Apex*, *Ensco MS-1* or similar), as the shallow water depth has ruled out the use of a DP MODU.

Specifications for the *Ocean Apex* and *Ensco MS-1* are detailed in **Table 3-1**. A MODU with similar specifications to these will be contracted for the Petroleum Activity Program.

Table 3-1: Current MODU specifications ranges for *Ocean Apex* and *Ensco MS-1*

Component	Specification Range
Rig type/design/class	Semi-submersible mobile offshore drilling unit
Accommodation	120–200 personnel (maximum persons on board)
Station keeping	Minimum eight point mooring system
Bulk mud and cement storage capacity	283–770 m^3
Liquid mud storage capacity	576–2500 m^3
Fuel oil storage capacity	966–1400 m^3
Drill water storage capacity	3500 m^3

Holding Station: Mooring Installation and Anchor Hold Testing/Soil Analysis

Mooring uses a system of chains/ropes and anchors, which may be pre-laid before the MODU arrives at the location, to maintain position when drilling. A mooring analysis will be undertaken to determine the appropriate mooring system for the Petroleum Activities Program. The mooring analysis will identify whether the mooring system will be pre-laid or set by the rig, proof tension values, or using synthetic fibre mooring ropes are required. A pre-laid system can generally withstand higher sea states compared to a system that only uses the rig’s mooring chain/equipment and saves the rig time in establishing anchors.

Installation and proof tensioning of anchors involves some disturbance to the seabed. Anchor handling vessels (AHV) are used in the deployment and recovery of the mooring system.

As part of mooring preparations, anchor hold testing may be conducted at the well locations. Anchor hold testing would be undertaken if Woodside determines that further assurance is required to ensure a robust mooring design.

Anchor hold testing may consist of an AHV or similar vessel dropping an anchor at a potential mooring location. The AHV would then tension the anchor to determine its ability to hold, embed and not drag at location. This may have to be repeated several times at each location. A remotely operated underwater vehicle (ROV) may also be utilised to judge how deep the anchor has embedded and independently verify the seabed condition. Anchor hold testing activities would occur prior to the MODU arriving on location.

Soil analysis may also be necessary to provide data on composition and rock/substrate strength as input into the mooring design - and verify seabed conditions for anchor holding. Soil analysis could include taking a physical sample of the seabed using ROV or other tools, or using measuring devices such as a cone penetrometer. These tests would be carried out up to several months prior to MODU arriving on location, and may occur from a support vessel or anchor handling vessel. Soil analysis is not required for the Achernar exploration well and therefore these activities are not required to be conducted prior to acceptance of this EP.

3.3.2 Installation Support Vessels

The Petroleum Activities Program may require an ISV with sufficient capacity to accommodate the Conductor Anchor Node (CAN) for the installation and removal of the conductor.

For installation, vessels are equipped with a variety of material handling equipment which includes cranes, winches, ROVs and ROV Launch and Recovery Systems (LARS). Lifting operations involve loading and unloading equipment onto the seabed. Cranes are typically equipped with active heave compensation and auto tension modes, and have lifting capacities in excess of lifting loads expected to be encountered during operations.

3.3.3 Support Vessels

During the Petroleum Activities Program, the MODU and ISV will be supported by other vessels, such as general support vessel(s) and AHVs.

Support vessels are used to transport equipment and materials between the MODU and port (e.g. Dampier or Exmouth). One vessel will be present at the MODU as required to perform standby duties as stipulated in the OneMarine Charterers Instructions, and others will transit out of the Operational Area to port for emergency and non-routine operations, approximately two to four trips per week.

The support vessels are also available to assist in implementation of the Oil Pollution First Strike Plan, should an environmental incident occur (e.g. spills).

3.3.4 Refuelling

The MODU will be refuelled via support vessels approximately once a month, or as required (different operations burn varying amounts of fuel). This activity will take place within the Operational Area of the well being drilled at the time and has been included in the risk assessment for this EP. Other fuel transfers that may occur on board the MODU include refuelling of cranes, helicopters or other equipment as required.

3.4 Other Support

3.4.1 Remotely Operated Vehicles

The MODU, ISV and support vessels may be equipped with a ROV system that is maintained and operated by a specialised contractor aboard the vessel. ROVs may be used prior to and during drilling operations, for activities such as:

- CAN installation and retrieval

- anchor holding testing
- pre-drill seabed and hazard survey
- BOP land-out and recovery
- BOP well control contingency
- visual observations at seabed during riserless drilling operation
- post-well seabed survey.

The ROV can be fitted with various tools and camera systems that can be used to capture permanent records (both still images and video) of the operations and immediate surrounding environment.

The ROV may also be used in the event of an incident for the deployment of the Subsea First Response Toolkit.

3.4.2 Helicopters

During the Petroleum Activities Program, crew changes will be undertaken using helicopters as required. Helicopter operations within the Operational Area are limited to helicopter take-off and landing on the MODU helideck. Helicopters may be refuelled on the heli-deck of the MODU. This activity will take place within the Operational Area of the well being drilled at the time and has been included in the risk assessment for this EP.

3.5 MODU and Vessel Activities

The MODU, ISV and support vessels will use diesel-powered generators for power generation.

The MODU, ISV and support vessels will display navigational lighting and external lighting, as required for safe operations. Lighting levels will be determined primarily by operational safety and navigational requirements under relevant legislation, specifically the *Navigation Act 2012*. The MODU, ISV and support vessels will be lit to maintain operational safety on a 24 hour basis.

A variety of materials are routinely bulk transferred from support vessels to the MODU including drilling fluids (e.g. muds), base fluids, cements, and drill water. A range of dedicated bulk transfer stations and equipment are in place to accommodate the bulk transfer of each type of material. There is also a capacity to bulk transfer waste oil from the MODU to the support vessel, for back loading and disposal on shore.

The loading and back-loading of equipment, materials and wastes is one of the most common supporting activities conducted during drilling programs. Loading and back-loading is undertaken using cranes on the MODU to lift materials in appropriate offshore rated containers (ISO tanks, skip bins, containers) between the MODU, ISV and support vessel.

Seawater is pumped on board and used as a heat exchange medium for the cooling of machinery engines on the MODU, ISV and support vessels. It is subsequently discharged from the MODU, ISV and support vessels to the sea surface at potentially a higher temperature. Alternately, the MODUs, ISV and support vessels may utilise closed loop cooling systems.

Potable water, primarily for accommodation and associated domestic areas, may be generated on vessels using a reverse osmosis (RO) plant. This process will produce brine, which is diluted and discharged at the sea surface.

The MODU, ISV and support vessels will also discharge deck drainage from open drainage areas, bilge water from closed drainage areas, putrescible waste and treated sewage and grey water. Solid hazardous and non-hazardous wastes generated during the Petroleum Activity Program are disposed of onshore and transported by support vessels.

3.6 Drilling Activities

Well construction activities are conducted in the stages described below. Detailed well designs will be submitted to the Well Integrity department of NOPSEMA as part of the Approval to Drill and the accepted Well Operation Management Plan (WOMP) as required under the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011.

3.6.1 Cement Unit Test

Upon arrival on location at the Operational Area, the MODU may be required to perform a cement unit test, or 'dummy cement job' to test the functionality of the cement unit and the MODU's bulk cement delivery system prior to performing an actual cement job. This operation is usually performed after a MODU has been out of operation for an amount of time (warm-stack), if maintenance on the cement unit has been carried out, or if it's the first time a MODU is being utilised in-country and commissioning of the cement unit system is required.

A 'dummy cement job' involves mixing a sacrificial cement slurry at surface, and once functionality of the cement unit and delivery system has been confirmed, the slurry is discharged through the usual cement unit discharge line (which may be up to 10 m above the sea level) or through drill pipe below sea level, and occur as a cement slurry. The slurry is usually a mix of cement and water however may sometimes contain stabilisers or chemical additives.

3.6.2 Top Hole Section Drilling

Petroleum Activity Program drilling commences with the top hole section as follows:

- The MODU arrives and establishes position over the well site.
- A pilot hole or holes may be drilled in close proximity to the intended well location. Pilot holes are used when confirmation of geology and shallow hazards is required or further understanding of the structural integrity of the rock is required. Pilot holes are drilled riserless, as described below, and result in additional cuttings, sweeps and potentially mud deposition to seabed.
- Top hole sections are typically drilled riserless using seawater with pre-hydrated bentonite sweeps/XC Polymer sweeps or drilling fluids to circulate drilled cuttings from the wellbore.
- Riseless mud recovery (RMR) provides the same function as a drilling riser, in which fluid and cuttings are return (by pumping) to the MODU where the drilling fluid is recovered through conventional means (shakers) and mud recycled down hole, and the cuttings are discharged at the sea surface by conventional means. The system allows the benefit of drilling with a weighted mud system (over a long interval) to improve for drilling conditions (e.g. borehole stability) in areas where a BOP and riser can't be run (e.g. due to wellhead configuration).
- Once each of the top hole sections are drilled, steel tubulars (called conductor or casing) are inserted into the wellbore to form the surface casing, and secured in place by pumping cement into the annular space back to approximately 300 m above the casing shoe, which may involve a discharge of excess cement at the seabed.

CAN Installation

An alternative method of conductor installation in top hole section drilling which may be employed during the Petroleum Activities Program is the CAN unit which is used for offline conductor installation (suction) via an ISV. The CAN is around 6 m diameter and 12–18 m in length, and is lowered down to the seabed via an ISV where an ROV is latched to the pump out port and starts pumping out water from the CAN. This creates a suction process which completes the CAN installation. Once CAN is in place, the rig positions above the wellhead which is preinstalled in the centre of the CAN and commences drilling. Using a CAN conductor marginally reduces the volume of drill cuttings and eliminates the need for cementing conductor casing. Should the CAN installation be unsuccessful, the 36" conductor will be drilled and installed as per usual operations.

If initial CAN installation is unsuccessful, the CAN may be retrieved or lifted off the seabed and moved to another location close-by to reattempt suction and embedment (analogous to a 're-spud' in traditional drilling).

Should CAN installation be undertaken, recovery of the CAN is proposed to be conducted with an ISV within ±6 months of the well finishing, pending ISV availability. The CAN is pumped out using a ROV. In the unlikely event the CAN does not come out it will be left on bottom with the wellhead in-situ as per well abandonment criteria.

Depending on the success of the CAN, it may be employed for multiple wells in the Petroleum Activities Program. It is possible to reuse the same CAN unit for multiple successive wells, or different units may be required, depending on the technical requirements (i.e. size/dimensions) of the individual wells.

3.6.3 Blowout Preventer and Marine Riser Installation

After setting the surface casing, a blowout BOP is installed on the wellhead to provide a means for sealing, controlling and monitoring the well during drilling operations. The operation of the BOP components uses open hydraulic systems (utilising water-based BOP control fluids). Each time the BOP is operated (including pressure testing approx. every 21 days and a function test approx. every seven days, excluding the week a pressure test is conducted), the maximum volume of BOP control fluid that will be released to the marine environment per well is up to 19,000 L of water based fluid containing approximately 570 L of control fluid additive.

Hydraulic fluid used for operation of the BOP rams is subject to the chemical assessment process outlined in **Section 3.7.2**.

A marine riser is installed to provide a physical connection between the well and MODU. This enables a closed circulation system to be maintained, where weighted water based muds (WBM) or non-water based muds (NWBM) and cuttings can be circulated from the wellbore back to the MODU, via the riser.

In the case of a CAN being present, the BOP is installed on top of the well-head existing on the CAN, as per normal operations.

3.6.4 Bottom Hole Section Drilling

A closed system (riser in place), is used for drilling bottom hole sections to the planned wellbore Total Depth (TD). Bottom hole sections are planned to be drilled using a combination of WBM and NWBM drilling fluids (**Section 3.7.2**).

Protective steel tubulars (casings and liners) are inserted as required. The size, length and inclination of the casing/liner sections within the wellbore is determined by factors such as the geology/subterranean pressures likely to be encountered in the area and any specific information or resource development requirements.

After a string of casing/liner has been installed into the wellbore, it is cemented into place. The casing/liner is then pressure tested. Once the pressure testing is passed, drilling can resume with the riser in place to circulate drill cuttings and drilling fluids back to the MODU.

Cementing operations are also undertaken to:

- provide annular isolation between hole sections and structural support of the casing as required
- set a plug in an existing well in order to sidetrack
- plug a well so it can be abandoned (**Section 3.6.8**).

Cements are transported as dry bulk to the MODU by the support vessels, mixed as required by the cementing unit on the MODU and are pumped by high pressure pumps to the surface cementing head then directed down the well.

Excess cement (dry bulk) after well operations are completed, will either be held onboard and used for subsequent wells; provided to the next operator at the end of the program or discharged to the marine environment. Excess cement that does not meet technical requirements during the Petroleum Activity Program may also be bulk discharged to the environment. Bulk discharges of cement may occur as a slurry through the usual cement discharge line, or blown as dry bulk and discharged just below the water line.

3.6.5 Formation Evaluation

Formation evaluation is the interpretation of a combination of measurements taken inside a wellbore to detect and quantify hydrocarbon presence in the rock adjacent to the well, once TD is reached. It may include extracting small cores, wireline logging, VSP, full diameter cores and other down-hole technologies, as required.

VSP is likely to be undertaken during the Petroleum Activities Program. VSP is used to generate a high-resolution seismic image of the geology in the well’s immediate vicinity. It uses a small airgun array, typically comprising either a system of three 250 cubic inch airguns with a total volume of 750 cui of compressed air or nitrogen at about 1800 psi (12,410 kPa) or two 250 $inch^3$ airguns with a total volume of 500 $inches^3$. During VSP operations, four to five receivers are positioned in a section of the wellbore (station) and the airgun array is discharged approximately five times at 20 second intervals. The generated sound pulses are reflected through the seabed and are recorded by the receivers to generate a profile along 60 to 75 m section of the wellbore. This process is repeated as required for different stations in the wellbore and it may take up to 24 hours to complete, depending on the wellbore’s depth and number of stations being profiled.

3.6.6 Well Clean-up

Prior to installing the DST string, wells will generally be displaced from the drilling fluid system to brine. A chemical cleanout fluids train will be circulated between the two fluids, then seawater or brine circulated until operational cleanliness specifications are met. This will be in line with Woodside's Reservoir, Drilling and Completions Fluids Guideline. Brine is typically a filtered brine with <70 nephelometric turbidity units (NTU) and/or <0.05% total suspended solids (TSS). This results in a brine and seawater discharge after this operation.

Should there be clean-up brine contaminated with NWBM drilling fluid or base oil, it will be captured and stored on the MODU for discharge or backloading to shore. Discharge may occur if the oil content is <1% hydrocarbon contamination by volume. For initial clean-up fluids (usually returned to the rig within the first few hours of circulation) which are predominantly drilling mud (concentration of mud compared to brine is a higher percentage of mud); NWBM will be retained and returned to shore if hydrocarbon contamination is not <1% by volume and WBM will be discharged as per requirements in this EP.

3.6.7 Drill Stem Testing

DST may also be carried out during the Petroleum Activities Program on the exploration or appraisal wells. DST involves flowing hydrocarbon fluids back to surface in a controlled manner by isolating targeted reservoir intervals with a special drill stem test bottom hole assembly, usually consisting of isolation packers and downhole valves. The test is used to determine the fluid properties and formation flow potential of the reservoir, and will vary in duration according to the test requirements. Disposal of hydrocarbons produced to surface will normally be done with flaring operations.

3.6.8 Well Abandonment

Well abandonment activities are conducted in accordance with the Engineering Standards - Well Barriers. Abandonment of exploration and appraisal wells drilled as part of this petroleum activity program may be required.

Base oil may be used for inflow testing prior to abandonment, to verify barrier integrity. Base oil would be pumped down the drill string and reverse circulated back to the rig, with collection of fluids for disposal onshore. If stored in a mud pit, the base oil and other fluids associated with the test may result in pit-wash water contaminated with hydrocarbons. If this is the case, mud pit wash water would be discharged in accordance with requirements in this EP; with a hydrocarbon content <1% by volume.

If required, wells will be abandoned with abandonment cement plugs, including verification of the uppermost cement plug by tagging and/or pressure testing through a prescribed program. Abandonment of a lower section of a well may also occur prior to sidetracking (**Section 3.8.2**).

Following abandonment activity, the marine riser and BOP will be removed, and retrieval of the wellhead and CAN (if used) will then occur.

Conventional wellheads are removed by deploying a cutting device on drill pipe which then cuts through the conductor allowing the wellhead to be retrieved to surface. Backup cutting equipment is sent offshore as a contingency should the primary set of equipment fail. The conductor cutting equipment is very reliable with a high success rate of cutting wellheads.

To remove the CAN if it has been used, the unit will be partially pumped out of the seabed at the end of plug and abandonment activities when the rig is on location. This is to ensure the internal casing has been cut and that there is no restriction for removal prior to the vessel arriving to complete removal activities. An ISV will then come and pump the rest of the CAN out; however, if there are geotechnical issues, it may be that the frictional forces holding the CAN in place cannot be overcome through pumping.

If these recognised removal techniques are ineffective, the wellhead may be left in-situ along with the Conductor Anchor Node. The integrity of the wellbore is not affected by the wellhead assembly remaining in-situ. (Refer to **Section 3.8.4** for additional details regarding leaving the wellhead assembly in situ).

3.7 Project Fluids

3.7.1 Assessment of Project Fluids

All downhole chemicals that may be operationally released or discharged to the marine environment by the Petroleum Activities Program are selected and approved in accordance with the Chemical Selection and Assessment Environment Guideline. This guideline is used to demonstrate that the potential impacts of the chemicals selected are acceptable, ALARP and consistent with the Environmental Performance Standards Procedure. All approved chemicals are included on the Drilling and Completions - Master Chemical List which is reviewed during a six month chemical review as per the Chemical Selection and Assessment Environment Guideline.

The chemical assessment process follows the principles outlined in the Offshore Chemical Notification Scheme (OCNS) which manages chemical use and discharge in the United Kingdom (UK) and the Netherlands. It applies the requirements of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). The OSPAR Convention is widely accepted as best practice for chemical management.

Chemicals fall into the following assessment types:

- No further assessment: Chemicals with an HQ band of Gold or Silver or an OCNS ranking of E or D with no substitution or product warnings do not require further assessment. Such chemicals do not represent a significant impact on the environment under standard use scenarios and are therefore considered ALARP and acceptable.
- Further assessment/ALARP justification required: Some types of chemicals require further assessment to understand the environmental impacts of discharge into the marine environment, specifically:
  - chemicals with no OCNS ranking
  - chemicals with an HQ band of white, blue, orange, purple or an OCNS ranking of A, B or C, or
  - chemicals with an OCNS product or substitution warning.

If no environmental data is available for a chemical or if the environmental data does not meet the acceptability criteria outlined above, potential alternatives for the chemical will be investigated, with preference for options with an HQ band of Gold or Silver, or are OCNS Group E or D with no substitution or product warnings.

If no more environmentally suitable alternatives are available, further risk reduction measures (e.g. controls related to use and discharge) will be considered for the specific context and implemented where relevant to ensure the risk is ALARP and acceptable.

3.7.2 Drilling Fluid System

Water Based Mud System

The Petroleum Activities Program will use a WBM drilling fluid system, which may be Ultradrill (commercial name), Flo-Pro or similar alternative WBM drilling fluid system. In addition to the base fluid, drilling muds contain a variety of chemicals, incorporated into the selected drilling fluid system to meet specific technical requirements (e.g. mud weight required to manage pressure). All chemicals selected for use have been assessed under the Chemical Selection and Assessment Environment Guideline.

The WBM drilling fluid will either be mixed on the MODU or received pre-mixed, then stored and maintained in a series of pits aboard the MODU. The bottom hole sections may be drilled using WBM in a closed circulation system which enables re-use of the WBM drilling fluids (**Section 3.7.2**). The top hole sections will be drilled riserless with seawater containing PHG sweeps, and cuttings and drilling fluids returned to the seabed (**Section 3.6.2**).

WBM drilling fluids that cannot be re-used (e.g. due to bacterial deterioration or do not meet required drilling fluid properties) or are mixed in excess of required volumes, may be operationally discharged to the ocean under the MODU's Permit to Work (PTW) system, using seawater flushing. Opportunities to reuse the WBM drilling fluids at the end of the Petroleum Activities Program are reviewed across current Woodside drilling activities.

WBM may not be able to be reused between drilling sections due to the drilling sequence, technical requirements of the mud (no tolerance for deterioration of mud during storage) and maintenance of productivity/injectivity.

A number of factors unique to each drilling program will determine the quantities of WBM drilling fluids required and subsequent discharge volumes if no suitable re-use option is available.

Non-water Based Mud System

The decision to use NWBM drilling fluids for the bottom hole sections of a particular well is based on a variety of technical factors relevant to wellbore conditions, such as: well temperature, well shape and depth, reactivity of the formation to water and well friction. The technical justification to use NWBM includes consideration of environment, health, safety and waste management.

The use of NWBM drilling fluids is subject to a formal written commercial and/or technical justification approved in accordance with the Best Practice – Overburden Drilling Fluids Environmental Requirements.

Novatec (commercial name) or similar alternative is likely to be selected, should the requirement for NWBM be approved. The main ingredient of NWBM is base oil (Novatec utilises Linear Alpha Olefin (LAO) or Saraline 185V alkane base oil). Similar to a WBM system, a range of standard solid and liquid additives may be added in the pits to alter specific mud properties for each section of the well, dependent on the conditions encountered while drilling.

The NWBM drilling fluid will be primarily mixed onshore and transferred to the MODU by a support vessel, where it is stored and maintained in the mud pits. During drilling operations, the NWBM drilling fluid, like the WBM, is pumped by high pressure pumps down the drill string and out through the drill bit, returning via the annulus between the drill string and the casing back to the MODU via the riser.

The used NWBM pumped back to the MODU contains drill cuttings and is pumped to the SCE, where the drill cuttings are removed before being pumped back to the pits ready for re-use. The properties of the NWBM drilling fluids are altered (e.g. to increase weight) using additives as required when in the mud pits.

The NWBM drilling fluids that cannot be re-used (i.e. do not meet required drilling fluid properties or are mixed in excess of required volumes) are recovered from the mud pits and returned to the shore base for onshore processing, recycling and/or disposal. The mud pits and associated equipment/infrastructure are cleaned when NWBM is no longer required, with wash water treated onboard through Solid Control Equipment (SCE) prior to discharge with mud pit washings or returned to shore for disposal if discharge criteria cannot be achieved (refer to mud pits below).

Mud Pits

There are typically a number of mud pits (tanks) on the MODU that provide a capacity to create (mix), maintain and store fluids required for drilling activities. The mud pits form part of the drilling fluid circulation system. The mud pits and associated equipment/infrastructure are cleaned out at the completion of drilling operations. Mud pit wash residue is operationally discharged with less than 1% oil contaminated by volume. Mud pit residue over 1% oil volume is sent to shore for disposal.

3.7.3 Drill Cuttings

Drill cuttings generated from the well are expected to range from very fine to very coarse (<1 cm) particle/sediment sizes. Cuttings generated during drilling of the top hole sections are discharged at the seabed. The bottom hole sections will be drilled with a marine riser that enables cuttings and drilling fluid to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the SCE. The SCE uses shale shakers to remove coarse cuttings from the drilling mud. After processing by the shale shakers, the recovered mud from the cuttings may be directed to centrifuges, which are used to remove fine solids (4.5 to 6 µm). The cuttings are usually discharged below the water line and the mud is recirculated into the fluid system.

If NWBM are needed to drill a well section, the cuttings from the NWBM drilling fluid system will also pass through a cuttings dryer and associated SCE to reduce the average oil on cuttings for the entire well (section using NWBM) to 6.9% wt/wt or less on wet cuttings prior to discharge.

3.8 Contingent Activities

The following sections present contingencies that may be required, if operational or technical issues occur during the Petroleum Activities Program. These contingencies have been considered within the relevant impact assessment sections and do not represent significant additional risks or impacts, but may generate additional volumes of drilling fluids and cuttings being operationally discharged.

3.8.1 Respud

A respud may be required for a number of reasons, such as if the conductor or well head slumps or fails installation criteria (typically during top hole drilling). Respudding involves moving the MODU to a suitably close location (e.g. ~50 m from the original location) to recommence drilling. A respud activity would result in repeating top hole drilling (**Section 3.6.2**).

3.8.2 Sidetrack

The option of a sidetrack instead of a respud may be determined, if operational issues are encountered. The environmental aspects of a sidetrack well are the same as those for undertaking routine drilling activities, which are considered to be adequately addressed by this with no significant changes to existing environmental risks or any additional environmental risks likely. The net environmental effect will be limited to an increase in the volume of cuttings generated, potential increase in the use of NWBM/WBM and the additional emissions (atmospheric and waste) associated with an extended drilling program.

3.8.3 Well Suspension

During drilling activities, a well may need to be temporarily suspended. Suspension involves establishing suitable barriers, removing the riser and disconnecting the MODU from the well. The BOP may sometimes be left in place to act as a barrier. Suspension may be short term (e.g. in the case of a cyclone) or longer term (more than one year). On return to a well following suspension, the MODU reconnects to the well via the riser, and with BOP in place, barriers are removed and drilling activity resumes.

3.8.4 Wellhead Assembly Left In-situ

On completion of a well, the wellhead assembly, along with CAN (if installed), may be left in-situ if recognised removal techniques are ineffective. Well abandonment activities would be undertaken as outlined in **Section 3.6.8**, but the well assembly would remain. The integrity of the wellbore is not affected by the wellhead assembly remaining in-situ.

3.8.5 Sediment Relocation

If required, a ROV-mounted suction pump/dredging unit may be used to relocate sediment/cuttings around the wellhead to keep the area clear and safe for operations and equipment. This activity could generate plumes of suspended sediment during pumping and cause disturbance to benthic fauna in the immediate area.

3.8.6 Venting

During drilling of the well, a kick may occur. A kick is an undesirable influx of formation fluid into the wellbore. To maintain well integrity in this situation, a small volume of greenhouse gases is released to the atmosphere via the degasser, in a well control operation known as ‘venting’.

3.8.7 Emergency Disconnect Sequence

An Emergency Disconnect Sequence (EDS) may be implemented if the MODU is required to rapidly disengage from the well. The EDS closes the BOP (i.e. shutting in the well) and disconnects the riser to break the conduit between the wellhead and MODU. Common examples of when this system may be initiated include the movement of the MODU outside of its operating circle (e.g. due to a failure of one or more of the moorings) or the movement of the MODU to avoid a vessel collision (e.g. third-party vessel on collision course with the MODU). EDS aims to leave the wellhead in a secure condition but will result in the loss of the drilling fluids/cuttings in the riser following disconnection.

4. DESCRIPTION OF THE RECEIVING ENVIRONMENT

The key existing environment characteristics, in line with the process of identifying and describing the existing environment in relation to the 'nature and scale' of the activity is provided below. The key existing environment characteristics are described in terms of the PAA and the Zone of Consequence (ZoC). The wider ZoC has been identified by hydrocarbon spill modelling of the credible worst case scenario (loss of well integrity) and includes surface, entrained and dissolved hydrocarbon phases of both crude and condensate scenarios.

The following is a summary of the main environment characteristics identified for the Permit Area and relevant to planned activities described within the EP:

- Located within Commonwealth waters within the Northwest Shelf Province (NWS), water depths within the PAA range between 100 to 129 m;
- The seabed in the PAA consists of sediments that generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the slope and abyssal plain;
- The ancient coastline at 125 m depth contour Key Ecological Feature (KEF) overlaps the PAA. The ancient coastline at 125 m depth contour KEF promotes mixing and productivity;
- Benthic communities are expected to be of a low abundance but high variability and diversity of infauna, dominated by polychaetes and crustaceans within the PAA; and
- Thirty species considered to be Matters of National Environmental Significance (MNES) may exist within, or transit through, the PAA. Three Biologically Important Areas (BIA) overlaps the PAA; a pygmy blue whale distribution BIA, a whale shark foraging BIA, and wedge-tailed shearwater breeding BIA.

4.1 Regional Setting

The PAA is located in Commonwealth waters within the Northwest Shelf Province (NWS) where water depths range between 0 and 200 m (DEWHA, 2008, DSEWPaC, 2012a). Water depths within the PAA range between 100 to 129 m. The NWS is part of the wider North-west Marine Region (NWMR) as defined under the Integrated Marine and Coastal Regionalisation of Australia (National Oceans Office and Geoscience Australia, 2005). The NWS is located primarily on the continental shelf between North West Cape and Cape Bougainville. It varies in width from about 50 km at Exmouth Gulf to more than 250 km off Cape Leveque and covers an area of 238,759 km^2 (DEWHA, 2008).

The NWS is characterised by the following biophysical features (DEWHA, 2008; DSEWPaC, 2012a):

- There are transitional climatic conditions between dry tropics to the South and humid tropics to the North.
- There are strong seasonal winds and moderate off-shore tropical cyclone activity.
- Deeper surface waters are tropical year-round and highly stratified during summer months (thermocline occurring at water depths between ~30 to 60 m). In winter, surface waters are well mixed with thermoclines (at ~120 m depth).
- Surface ocean circulation is strongly influenced by the Indonesian Throughflow (ITF) via the Eastern Gyre. During the summer when the ITF is weaker, South West winds cause intermittent reversals in currents. These events may be associated with occasional weak shelf upwellings.
- The seabed in the region consists of sediments that generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the slope and abyssal plain. Approximately 60-90 % of the sediments in the region are carbonate derived

(Brewer *et al.,* 2007). The distribution and re-suspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic cyclones. Further offshore, on the mid to outer shelf and on the slope, sediment movement is primarily influenced by ocean currents and internal tides, the latter causing re-suspension and net down-slope deposition of sediments (DSEWPaC, 2012a).

- The region has high species richness, but a relatively low level of endemism, i.e. species particular to the region in comparison to other areas of Australian waters. Furthermore, the majority of the region’s species are tropical and are recorded in other areas of the Indian Ocean and Western Pacific Ocean.
- Benthic communities range from nearshore benthic primary producer habitats such as seagrass beds, coral communities and mangrove forests to offshore soft sediment seabed habitats associated with low density sessile and mobile benthos such as sponges, molluscs and echinoids (with noted areas of sponge hotspot diversity).
- Internationally significant migratory routes, resident populations, breeding and/or feeding grounds are present for a number of EPBC Act listed threatened and migratory marine species, including humpback whales, marine turtles, whale sharks, seabirds and migratory shorebirds.
- Key Ecological Features (KEFs) in the region include the high diversity Continental Slope Demersal Fish Communities and Ancient coastline at 125 m depth contour, which may promote mixing and productivity. Rankin Banks and Glomar Shoals which are offshore submerged shoals are also notable features in the region.

The wider ZoC overlaps six provincial bioregions within the NWMR, as well as three within the South-west Marine Region (SWMR). Provinces within the NWMR include the Northwest Shelf, Northwest, Timor, Northwest Transition, Central Western Transition and Central Western Shelf Transition. Within the SWMR, the Central Western Shelf, Central Western Province and Southwest Shelf Transition overlap the ZoC.

4.2 Physical Environment

The climate of the NWMR is dry tropical, and exhibits a hot summer season from October to April and milder winter season between May and September (BOM, 2017). There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds (Pearce *et al*., 2001).

Air temperatures in the region, as measured at the Barrow Island meteorological station (approximately 155 km south-east from the PAA), during summer reach an average of 35 ºC in March, falling to an average maximum of 24 ºC in July (BOM, 2017). Average minimum temperatures range from 26 ºC in February to 17 ºC in July (BOM, 2017).

The region experiences a tropical monsoon climate, with distinct wet (January to July) and dry (August to November) seasons. Rainfall in the region typically occurs during the wet season, with highest falls observed during late summer, often associated with the passage of tropical low pressure systems and cyclones (Pearce *et al*., 2003).

Tropical cyclones are a relatively frequent event for the NWMR, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast (Bureau of Meteorology, n.d.). Tropical cyclone activity can occur between November and April and is most frequent during December to March (i.e. considered the peak period), with an annual average of approximately one storm per month. Cyclones are less frequent in the months of November and April. Based on 47 years of historical weather data from 1970 until 2016, 32 tropical cyclones have occurred within 100 km of the PAA (Bureau of Meteorology, n.d.).

The large-scale ocean circulation of the NWS is primarily influenced by the ITF (Meyers *et al*., 1995; Potemra *et al*., 2003), and the Leeuwin Current (Godfrey and Ridgway, 1985; Holloway and Nye, 1985; Batteen *et al*.,1992; James *et al*., 2004). Both of these currents are significant drivers of the region's ecosystems. The currents are driven by pressure differences between the equator, and the higher density, cooler and more saline waters of the Southern Ocean. The currents are strongly influenced by seasonal change, and El Niño and La Niña episodes (DSEWPaC, 2012a). The ITF and Leeuwin Current are strongest during late summer and winter (Holloway and Nye, 1985; James *et al*., 2004). Flow reversals to the North East associated with strong South Westerly winds are typically weak and short lived but can generate upwelling of cold deep water onto the shelf (Holloway and Nye, 1985; James *et al*., 2004; Condie *et al*., 2006).

In addition to the synoptic-scale current dynamics, tidally driven currents are a significant component of water movement on the NWS. Wind driven currents become dominant during the neap tide (Pearce *et al*., 2003). In summer, the stratified water column and large tides can generate internal waves over the upper slope of the NWS (Craig, 1988). As these waves pass the shelf break at approximately 125 m depth, the thermocline may rise and fall by up to 100 m in the water column (Holloway and Nye, 1985; Holloway, 1988). Internal waves on the NWS are confined to water depths between 70 and 1000 m and the dissipation energy from such waves can enhance mixing in the water column (Holloway *et al*., 2001).

Tides in the NWS region are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the South East and ebbing towards the North West (Pearce *et al*., 2003). The region exhibits a considerable range in tidal height, from microtidal ranges (<2 m) South West of Barrow Island to macrotidal (>6 m) North of Broome (Holloway, 1983; Heyward *et al*., 2006; Brewer *et al*., 2007). Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights (Pearce *et al*., 2003).

The bathymetry of the NWMR is characterised by four distinct zones: the inner continental shelf, the middle continental shelf, the outer shelf/continental slope and the abyssal plain. A section of the Ancient Coastline at 125 m Depth Contour KEF also overlaps the PAA. Areas of this KEF comprise rocky hard substrate, which may occur within the PAA; however, the area is predominantly made up of soft sediment.

The PAA is located in waters 100 to 129 m deep on the outer shelf of the NWS. Broad-scale surveys confirm that the seabed is flat and relatively featureless with few areas of hard substrate or outcrops, except in areas within the Ancient Coastline at 125 m Depth Contour KEF. The seabed in the vicinity of the North Rankin Complex (approximately 12 km west of the PAA) is typical of deeper offshore areas (>150 m water depth) on the NWS, being characterised by deep (>5 m) soft, silty sediments derived primarily from calcium carbonate, which become deeper, softer and finer with increasing depth.

4.3 Biological environment

No Critical Habitats or Threatened Ecological Communities as listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) are known to occur within the PAA.

4.3.1 Benthic communities

Benthic grab sampling around the NRC platform approximately 12 km west of the PAA (Heyward *et al*., 2001) revealed a low abundance but high variability and diversity of infauna, dominated by polychaetes and crustaceans.

Sedimentary infauna associated with soft unconsolidated sediments around the Angel platform approximately 30 km east of the PAA is widespread and well represented along the continental shelf and upper slopes in the NWS region (Woodside, 2004; SKM, 2006; Brewer *et al*., 2007; RPS, 2011). Other NWS sampling programs have also indicated a widespread and well represented infauna assemblage along the continental shelf and upper slopes (Rainer, 1991; LeProvost, Dames and

Moore, 2000; RPS, 2011). Consequently, benthic habitat within the PAA, which consists of soft unconsolidated sediments, is considered to be of relatively low environmental sensitivity.

Within the wider ZoC, the NWMR has been identified as a sponge diversity hotspot with a variety of areas of potentially high and unique sponge biodiversity, particularly in the Commonwealth waters of Ningaloo Marine Park (CALM, 2005; Rees *et al*., 2004), 299 km from the PAA. Filter feeder communities in the wider ZoC region are primarily located in the deeper waters of the Ningaloo Reef system as well as the Muiron Islands, Rowley Shoals, and nearshore waters of the Pilbara Islands. Notable offshore filter feeders and deepwater benthic communities also occur at Rankin Bank. Filter feeders also make up minor components of the benthic communities at Rankin Bank (approximately 69 km south-west of the PAA), approximately 3% of the benthic cover, with sponges among the most abundant filter feeders (AIMS, 2014). Benthic communities at Rankin Bank are similar to those recorded at other shoals in the NWMR (AIMS, 2014) and are considered to be representative of the broader benthic communities within the ZoC.

4.3.2 Plankton

Zooplankton within the PAA is expected to be similar to offshore waters in the NWMR. The zooplankton in the region includes the larval stages of many organisms such as corals and fishes (Sampey *et al*., 2004). The inshore ichthyoplankton assemblage is characterised by shallow reef fishes such as blennies (family Blenniidae), damselfish (family Pomacentridae) and North West snappers (family Lethrinidae), while offshore assemblages are dominated by deepwater and pelagic taxa such as tuna (family Scombridae) and lanternfish (family Myctophidae) (Beckley *et al*., 2009). Some of these taxa are commercially and recreationally important species in the region.

Phytoplankton within the PAA is expected to reflect the conditions of the NWMR. Primary productivity of the NWS is largely driven by offshore influences (as reported by Brewer *et al*., 2007), with periodic upwelling events and cyclonic influences driving coastal productivity, and with nutrient recycling and advection. Cyanobacteria and diatoms are the predominant phytoplankton contributors. It is expected that the dominant primary consumers are copepods, with a wide range of secondary consumers, comprising larger planktonic taxa (including larval fish and invertebrates) (Brewer *et al*., 2007).

4.3.3 Species

A total of 30 EPBC Act listed species considered to be MNES (i.e. listed as threatened or migratory) were identified as potentially occurring within the PAA (**Table 4-1**). Of these 14 are considered threatened marine species and 30 migratory species under the EPBC Act.

Table 4-1 Threatened and migratory marine species under the EPBC Act potentially occurring with the PAA or within the wider ZoC

Species Name	Common Name	Threatened Status	Migratory Status	PAA/ ZoC
Mammals				
Balaenoptera borealis	Sei Whale	Vulnerable	Migratory	PAA
Balaenoptera musculus	Blue Whale	Endangered	Migratory	
Balaenoptera physalus	Fin Whale	Vulnerable	Migratory	
Megaptera novaeangliae	Humpback Whale	Vulnerable	Migratory	
Balaenoptera edeni	Bryde's Whale	N/A	Migratory	
Orcinus orca	Killer Whale, Orca	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	PAA/ ZoC
Physeter macrocephalus	Sperm Whale	N/A	Migratory	
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	N/A	Migratory	
Balaena glacialis australis	Southern Right Whale	Endangered	Migratory	ZoC
Dugong dugon	Dugong	N/A	Migratory	
Balaenoptera bonaerensis	Antarctic Minke Whale, Dark-shoulder Minke Whale	N/A	Migratory	
Sousa chinensis	Indo-Pacific Humpback Dolphin	N/A	Migratory	
Reptiles				
Caretta caretta	Loggerhead Turtle	Endangered	Migratory	PAA
Chelonia mydas	Green Turtle	Vulnerable	Migratory	
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	Endangered	Migratory	
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	Migratory	
Natator depressus	Flatback Turtle	Vulnerable	Migratory	
Lepidochelys olivacea	Olive Ridley Turtle, Pacific Ridley Turtle	Endangered	N/A	ZoC
Aipysurus apraefrontalis	Short-nosed Seasnake	Critically endangered	N/A	
Sharks, Fish and Rays				
Carcharodon carcharias	White Shark, Great White Shark	Vulnerable	Migratory	PAA
Rhincodon typus	Whale Shark	Vulnerable	Migratory	
Pristis zijsron	Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable	Migratory	
Anoxypristis cuspidata	Narrow Sawfish, Knifetooth Sawfish	N/A	Migratory	
Isurus oxyrinchus	Shortfin Mako, Mako Shark	N/A	Migratory	
Isurus paucus	Longfin Mako	N/A	Migratory	
Manta birostris	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	PAA/ ZoC
Manta alfredi	Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	N/A	Migratory	
Lamna nasus	Porbeagle, Mackerel Shark	N/A	Migratory	ZoC
Pristis clavata	Dwarf Sawfish, Queensland Sawfish	Vulnerable	Migratory	
Pristis pristis	Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish	Vulnerable	Migratory	
Milyeringa veritas	Blind Gudgeon	Vulnerable	N/A	
Carcharias taurus	Grey Nurse Shark (west coast population)	Vulnerable	N/A	
Ophisternon candidum	Blind Cave Eel	Vulnerable	N/A	
Birds				
Calidris canutus	Red Knot, Knot	Endangered	Migratory	PAA
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Critically endangered	Migratory	
Anous stolidus	Common Noddy	N/A	Migratory	
Calonectris leucomelas	Streaked Shearwater	N/A	Migratory	
Fregata ariel	Lesser Frigatebird, Least Frigatebird	N/A	Migratory	
Fregata minor	Great Frigatebird, Greater Frigatebird	N/A	Migratory	
Actitis hypoleucos	Common Sandpiper	N/A	Migratory	
Calidris acuminata	Sharp-tailed Sandpiper	N/A	Migratory	
Calidris melanotos	Pectoral Sandpiper	N/A	Migratory	
Pandion haliaetus	Osprey	N/A	Migratory	ZoC
Calidris ferruginea	Curlew Sandpiper	Critically endangered	Migratory	
Diomedea amsterdamensis	Amsterdam Albatross	Endangered	Migratory	
Diomedea exulans (sensu lato)	Wandering Albatross	Vulnerable	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	PAA/ ZoC
Limosa lapponica baueri	Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit	Vulnerable	Migratory	
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)	Critically endangered	Migratory	
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel	Endangered	Migratory	
Macronectes halli	Northern Giant Petrel	Vulnerable	Migratory	
Pterodroma mollis	Soft-plumaged Petrel	Vulnerable	N/A	
Rostratula australis	Australian Painted Snipe	Endangered	N/A	
Sternula nereis nereis	Australian Fairy Tern	Vulnerable	N/A	
Anous tenuirostris melanops	Australian Lesser Noddy	Vulnerable	N/A	
Diomedea sanfordi	Northern Royal Albatross	Endangered	N/A	
Papasula abbotti	Abbott's Booby	Endangered	N/A	
Thalassarche carteri	Indian Yellow-nosed Albatross	Vulnerable	Migratory	
Thalassarche cauta cauta	Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Migratory	
Thalassarche cauta steadi	White-capped Albatross	Vulnerable	Migratory	
Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	Vulnerable	Migratory	
Thalassarche melanophris	Black-browed Albatross	Vulnerable	Migratory	
Apus pacificus	Fork-tailed Swift	N/A	Migratory	
Ardenna carneipes	Flesh-footed Shearwater, Fleshy-footed Shearwater	N/A	Migratory	
Ardenna pacifica	Wedge-tailed Shearwater	N/A	Migratory	
Calonectris leucomelas	Streaked Shearwater	N/A	Migratory	
Hydroprogne caspia	Caspian Tern	N/A	Migratory	
Onychoprion anaethetus	Bridled Tern	N/A	Migratory	
Phaethon lepturus	White-tailed Tropicbird	N/A	Migratory	
Phaethon rubricauda	Red-tailed Tropicbird	N/A	Migratory	
Sterna dougallii	Roseate Tern	N/A	Migratory	
Sternula albifrons	Little Tern	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	PAA/ ZoC
Calidris alba	Sanderling	N/A	Migratory	
Charadrius veredus	Oriental Plover, Oriental Dotterel	N/A	Migratory	
Glareola maldivarum	Oriental Pratincole	N/A	Migratory	
Thalasseus bergii	Crested Tern	N/A	Migratory	
Tringa nebularia	Common Greenshank, Greenshank	N/A	Migratory	

Seabirds

Forty-seven listed species of seabirds and shorebirds were identified as potentially occurring within the wider ZoC (**Table 4-1**). Twenty-one of these species are listed as threatened under the EPBC Act. There are several important habitats for seabirds and migratory shorebirds within the wider ZoC, including key breeding/nesting areas, roosting areas and surrounding waters important foraging and resting areas.

The PAA may be occasionally visited by migratory and oceanic birds but does not contain any emergent land that could be utilised as roosting or nesting habitat and contains no known critical habitats (including feeding) for any species. Nine species of listed birds were identified by the EPBC Act Protected Matters Search for the PAA, of which only two are listed as threatened (**Table 4-1**):

- eastern curlew, listed as Critically Endangered and Migratory
- red knot, listed as Endangered and Migratory
- common noddy, listed as Migratory
- common sandpiper, listed as Migratory
- sharp-tailed sandpiper, listed as Migratory
- pectoral sandpiper, listed as Migratory
- lesser frigatebird, listed as Migratory
- great frigatebird, listed as Migratory
- streaked shearwater, listed as Migratory.

Marine Mammals

There are no known mating or calving areas for the sei whale, or other BIAs for sei whales in Australian waters (DoE, 2016a). The species has a preference for deep waters, and typically occurs in oceanic basins and continental slopes (Prieto *et al*., 2012); records of the species occurring on the continental shelf (<200 m water depth) are uncommon in Australian waters (Bannister *et al*., 1996a). Given the PAA is located in shallower waters (<200 m water depth), occurrence of Sei whales is expected to be infrequent within the PAA, and wider ZoC, mainly during winter months when the species may move away from Antarctic feeding areas.

The PAA overlaps with the pygmy blue whale distribution (known to occur) BIA. One additional pygmy blue whale BIA occurs within the wider ZoC. This is a foraging BIA in Ningaloo Reef/North West Cape region, approximately 346 km south-west of the PAA. Pygmy blue whales are unlikely to occur within the PAA but would be present in the wider ZoC, particularly during their defined annual migrations. When individuals do occur in the PAA, it is likely there will be only one or few individuals and their time in the area will be short in duration.

Fin whales are thought to follow oceanic migration paths, and are uncommonly encountered in coastal or continental shelf waters. The Australian Antarctic waters are important feeding grounds for fin whales but there are no known mating or calving areas in Australian waters (Morrice *et al*., 2004). There are no known BIAs for fin whales in the NWMR. As such, the species is likely to infrequently occur within the PAA, and wider ZoC, mainly during winter months when the species may move away from Antarctic feeding areas.

The humpback migration BIA lies 35 km south of the PAA at its closest point, with a resting BIA 296 km from the PAA. Exmouth Gulf (340 km south-west of the PAA) and Shark Bay (640 km south-west of the PAA) are known resting/aggregation areas for southbound humpback whales. In particular, Exmouth Gulf is where cow/calve pairs may stay for up to two weeks. Both Exmouth Gulf and Shark Bay are within the ZoC.

Antarctic minke whale calls were recorded near Scott Reef (826 km north-east of the PAA) on a logger deployed to the south-east of South Scott Reef. Calls were detected for a few days each year in 2006 to 2008 between July and October (McCauley and Duncan, 2011). No calls from this species were identified on other loggers set inside and outside of the reef. The presence of Antarctic minke whales in the PAA is unlikely, and occurrence within the ZoC is likely to be rare and limited to a few individuals infrequently transiting the area. Higher probability of occurrence may align with identified whale calls near Scott Reef. There are no known BIAs for Antarctic minke whales in the NWMR.

The presence of Bryde’s whales in the PAA is likely to be a remote occurrence and limited to a few individuals. In the wider ZoC, occurrence is likely to be limited, aside from foraging aggregations noted in Shark Bay during the summer period. There are no known BIAs for Bryde’s whales in the NWMR.

The sperm whale is known to migrate northwards in winter and southwards in summer but detailed information on the distribution and migration patterns of sperm whales off the WA coast is not available. Given the wide distribution of sperm whales, the PAA is unlikely to represent an important habitat for this species. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area.

Southern right whales were not identified as occurring within the PAA, but were identified as potentially occurring within the wider ZoC. However, given the species prefers temperate waters and has rarely been recorded north of Exmouth southern right wales are likely to only rarely occur in only the southern portion of the ZoC.

Given the wide distribution of killer whales and their preference for colder waters, the PAA is unlikely to represent an important habitat for this species. Outside of feeding periods at Shark Bay, the species’ presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the wider ZoC.

The spotted bottlenose dolphin may be present in the wider ZoC, although were not identified as occurring within the PAA. The spotted bottlenose dolphin is generally considered to be a warm water subspecies of the common bottlenose dolphin. Their distribution is primarily inshore waters, often in depths of less than 10 m (Bannister *et al*., 1996a).

Dugongs may be present in the wider ZoC, although were not identified as occurring within the PAA, as these large herbivorous marine mammals generally inhabit coastal areas. The species is distributed along the WA coast throughout the Gascoyne, Pilbara and Kimberley, with notable populations in the following areas which overlap the wide ZoC (DSEWPaC, 2012a; Marsh *et al*., 2002; Preen *et al*., 1997):

- Ningaloo Marine Park (state waters) (approximately 299 km south-west of the PAA)

- Exmouth Gulf (which is a listed foraging/breeding/nursing/calving BIA, approximately 340 km south-west of the PAA)
- Shark Bay (hosting the largest resident population in Australia, approximately 640 km south-west of the PAA).

Marine Reptiles

Five of the six marine turtle species recorded for the NWMR have the potential to occur within the PAA: the loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle and the flatback turtle. The Olive Ridley turtle may occur within the ZoC for foraging, feeding or related behaviour.

There is no emergent habitat for marine turtles within the PAA, and therefore, nesting aggregations of marine turtles would not be expected. No known marine turtle BIAs overlap the PAA, but a number occur within the wider ZoC, relating to the flatback, loggerhead, green and hawksbill turtles. Leatherback turtles are not confirmed as a nesting species within WA (Limpus, 2009a), nor have any other BIAs been identified for them in the region.

The nearest BIA is a flatback turtle internesting area, which extends for 80 km from the nesting beaches on the northern end of the Montebello Islands (24 km from the PAA at its closest point). The BIA is considered very conservative as it is based on the maximum range of the internesting females. However, many turtles are likely to remain near to their nesting beaches, and as they leave beaches they typically spread out and consequently, density decreases rapidly with increasing distance from a nesting beach (Waayers *et al*., 2011; Whittock *et al*., 2014). It is also possible that marine turtles forage in shallow waters along the mainland coastline, as well as around offshore islands and shoals.

Additional BIAs for green, loggerhead, flatback and hawksbill turtles within the wider ZoC include significant nesting rookeries on beaches along the mainland coast and islands, including the Montebello/Barrow/Lowendal Islands, Muiron Islands, North West Cape, Ningaloo Reef and the Dampier Archipelago (Environment Australia, 2003; Limpus, 2007, 2008a, 2008b, 2009b).

The short-nosed seasnake, listed as Critically Endangered under the EPBC Act, was the only seasnake species to be identified within the Protected Matters Search reports (identified as occurring within the wider ZoC only). This species has been previously recorded on the Sahul Shelf, in particular at Ashmore and Hibernia reefs (outside the ZoC).

Sharks, Rays and Fishes

Great white sharks were identified as occurring within the PAA and ZoC. However, given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), great white sharks are unlikely to occur within the PAA. Occurrence is likely within the ZoC near Shark Bay and its surrounds due to the presence of suitable prey (Australian sea lions).

The shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana *et al*., 2005). Tagging studies indicate shortfin makos spent most of their time in water less than 50 m deep, but with occasional dives up to 880 m (Abascal *et al*., 2011; Stevens *et al*., 2010). Little is known about the population size and distribution of shortfin mako sharks in WA; however, they were identified as occurring within both the PAA and ZoC; therefore, the species may occur within these areas.

Longfin mako sharks may occur in the PAA or ZoC, but given their widespread and highly dispersed distribution they are expected to be uncommon.

Occurrence of giant manta rays within the PAA is likely to be infrequent, and restricted to individuals transiting the area. In the wider ZoC, giant manta rays will occur, particularly in areas and during temporal periods noted here.

A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier *et al*., 2011). The reef manta ray is likely to occur within the wider ZoC, particularly near suitable habitat such as the Ningaloo Reef, and has the potential to occur within the PAA.

The narrow sawfish may occur in the PAA and wider ZoC, particularly in nearshore estuarine environments within the northern region of the ZoC.

The dwarf sawfish was not identified as occurring within the PAA; however, the species may be present in coastal waters within the wider ZoC.

Green sawfish were identified as occurring within the PAA, with occurrence within the broader ZoC likely within mangroves and tidal creek areas.

The freshwater sawfish was not identified within the PAA, and the ZoC does not overlap with any significant nursery areas for the species; however, it is likely to occur within the ZoC within 100 km of the WA shoreline.

Satellite tracks of whale sharks moving in a north-east direction show individuals do transit the PAA; also confirmed by the Protected Matters Search report. It is possible whale sharks will occur in this area, particularly prior to and following annual migrations. Within the wider ZoC, whale sharks are expected to be present, particularly during these aggregation periods and within known foraging areas or migration pathways.

Grey nurse sharks may occur within the PAA, but will likely be more likely to occur in some areas of the ZoC, particularly areas of relatively shallow temperate waters.

As both the blind gudgeon and blind cave eel live in caves and groundwater, it is highly unlikely that they would occur within the PAA. However, they may occur within the ZoC in caves and groundwater near the Cape Range Peninsula and the blind gudgeon may also be present within the ZoC at Barrow Island.

Southern Bluefin Tuna are likely to occur within the PAA and ZoC, particularly during summer when juveniles migrate southwards.

4.4 Socio-Economic and Cultural

4.4.1 Heritage

European and/or Indigenous Sites of Significance

There are no known sites of Indigenous or European cultural heritage significance within the vicinity of the PAA.

Within the wider ZoC area, Barrow Island, Montebello Islands, southern Pilbara coast, Exmouth, Shark Bay, Ningaloo Reef and the adjacent foreshores have a long history of occupancy by Aboriginal communities. Indigenous heritage places are protected under the *Aboriginal Heritage Act 1972* (WA) or EPBC Act.

Historic Shipwrecks

A search of the National Shipwreck Database (DoEE, 2018) indicated that there are no known historic shipwrecks within the PAA; however, 150 records of known historic shipwrecks were found within the ZoC.

National and Commonwealth Heritage Listed Places

There are no gazetted and proposed National and Commonwealth heritage places within the PAA; however, there are a number of places in the wider ZoC, including:

- National Heritage places:
  - the proposed Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves National Heritage Place (approximately 100 km south-east of the PAA)
  - the Ningaloo Coast National Heritage Area (approximately 320 km south-west of the PAA)
  - Shark Bay National Heritage Area (approximately 650 km south-west of the PAA)
  - HMAS Sydney II and HSK Kormoran Shipwreck Sites (approximately 850 km south of the PAA).
- Commonwealth Heritage places:
  - Ningaloo Marine Area (Commonwealth Waters) Commonwealth Heritage Place (approximately 330 km south-west of the PAA)
  - Mermaid Reef – Rowley Shoals (approximately 300 km east of the PAA).

4.4.2 Commonwealth and State Fisheries

Little fishing effort occurs in the PAA due to the water depth and distance from shore. Commonwealth fisheries designated management areas within the PAA and the ZoC include the following:

- North West Slope Trawl Fishery;
- Southern Bluefin Tuna Fishery;
- Western Skipjack Fishery;
- Western Tuna and Billfish Fishery; and
- Western Deepwater Trawl Fishery.

State fisheries designated management areas within the PAA and the ZoC include the following:

- Mackerel Managed Fishery;
- South West Coast Salmon Managed Fishery;
- West Coast Deep Sea Crustacean Managed Fishery;
- Pearl Oyster Managed Fishery;
- Abalone Managed Fishery;
- Marine Aquarium Fish Managed Fishery;
- Specimen Shell Managed Fishery;
- Pilbara Demersal Scalefish Managed Fisheries (Pilbara Trawl, Trap and Line);
- Onslow Prawn Managed Fishery;
- Kimberley Gillnet and Barramundi Limited Entry Fishery;
- West Coast Rock Lobster Fishery;
- Shark Bay Pawn and Scallop Managed Fisheries;
- Gascoyne Demersal Scalefish Managed Fishery;

- Nickol Nay Prawn Managed Fishery;
- Exmouth Gulf Prawn Managed Fishery;
- Shark Bay Blue Swimmer Crab Fishery;
- Northern Demersal Scalefish Managed Fishery;
- Broome Prawn Managed Fishery;
- West Coast Demersal Gillnet & Longline Fishery;
- West Coast Demersal Scalefish Fishery;
- Abrolhos Islands and Mid West Trawl Managed Fishery;
- Octopus Interim Managed Fishery;
- Shark Bay Beach Seine and Mesh Net Limited Entry Fishery;
- Exmouth Gulf Prawn Managed Fishery; and
- Shark Bay Scallop Managed Fishery.

There are no aquaculture activities within or adjacent to the PAA.

There are no traditional, or customary, fisheries within the PAA, as these are typically restricted to shallow coastal waters and/or areas with structure such as reef.

4.4.3 Tourism

No tourism activities take place specifically within the PAA but it is acknowledged that there are growing tourism and recreational sectors in Western Australia and these sectors have expanded in area over the last couple of decades.

Due to the PAA's water depths (between 100 and 129 m) and distance offshore (approximately 100 km north-west of the Dampier Peninsula), recreational fishing is unlikely to occur in the PAA.

4.4.4 Shipping activity

No shipping fairways intersect the PAA; however, significant shipping associated with entry to the ports of Dampier and Barrow Island occurs in close proximity to the PAA (**Figure 4-1**). Data provided through consultation with AMSA confirms vessel traffic does currently occur within the PAA.

The broader NWMR supports significant commercial shipping activity, the majority of which is associated with the mining and oil and gas industries. The nearest fairways are approximately 50 km east and 50 km west of the PAA at the closest point (**Figure 4-1**). Ports in the region are nodes of increased vessel activities; active ports in the greater vicinity of the PAA include:

- Dampier (approximately 100 km south-east of the PAA)
- Barrow Island (approximately 100 km south-west of the PAA)
- Onslow (approximately 250 km south-west of the PAA)
- Exmouth (approximately 350 km south-west of the PAA).

Additional shipping routes are located within the wider ZoC, and it is expected that local vessel traffic will pass through the area. Shipping activities in the region include:

- international bulk freighters/tankers including mineral ore, hydrocarbons (liquefied natural gas, liquefied petroleum gas, condensate) and salt carriers
- domestic support/supply vessels servicing offshore facilities and Barrow Island development

- construction vessels/barges/dredges
- offshore survey vessels
- commercial and recreational fishing vessels.

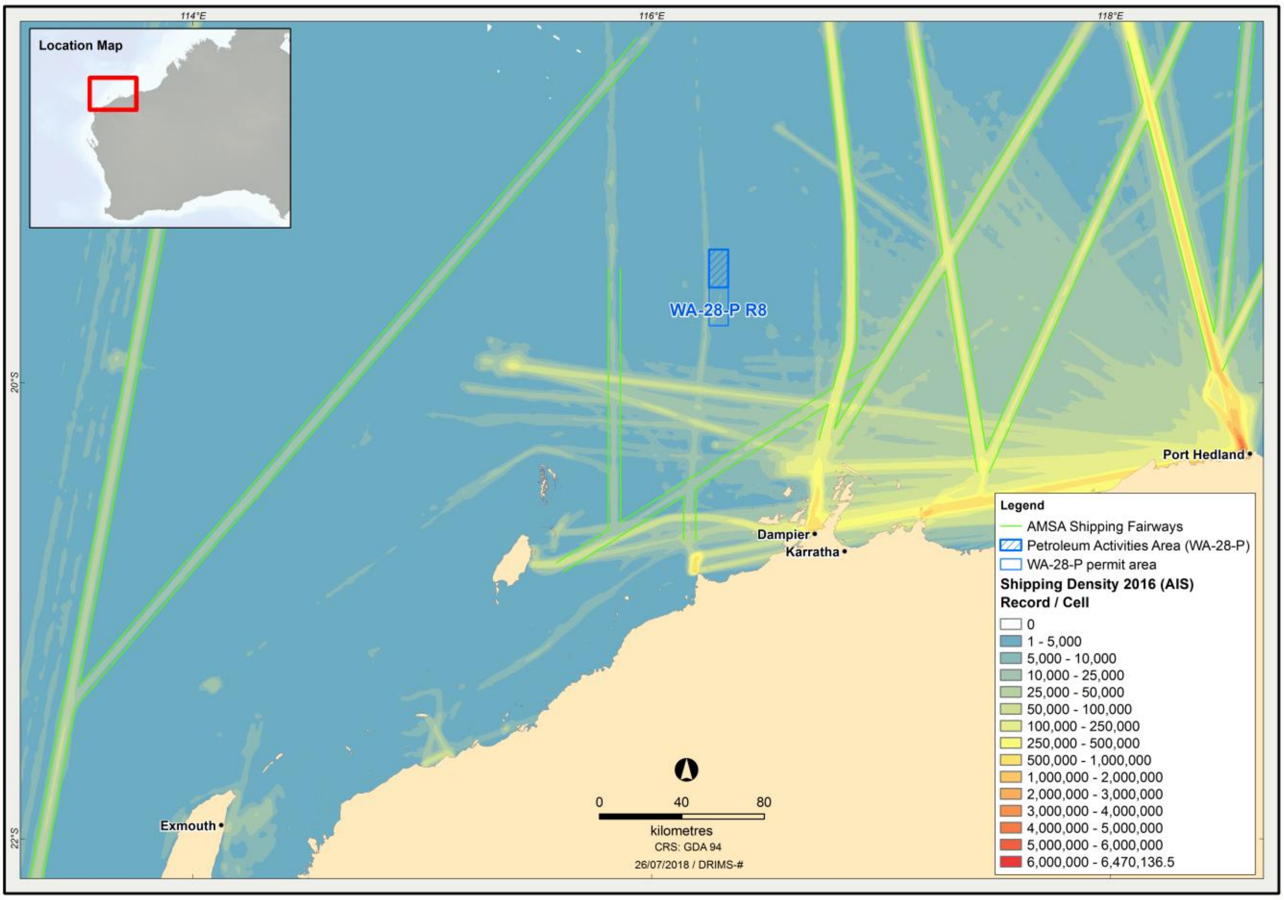

Figure 4-1: Vessel density map for the PAA from 2016, derived from AMSA satellite tracking system data

4.4.5 Oil and gas activity

The PAA is located within an area of established oil and gas operations in the broader NWMR. The PAA is approximately 25 km west of the North Rankin Complex (NRC) and 35 km east of the Angel platform operated by Woodside. Several Floating Production Storage and Offloading (FPSO) units and other facilities are currently in operation in the wider vicinity of the PAA and within the ZoC, including the Okha FPSO (10 km west).

Additionally, one live pipeline traverses the PAA; a gas export pipeline from the Angel Platform to the NRC. One existing well, Eaglehawk-1, is also present in the PAA. This well was permanently plugged and abandoned in 1972 following drilling in accordance with the applicable legislation at the time. The wellhead remains in situ and is managed under the North Rankin Complex Well Management Plan (WOMP).

4.4.6 Defence

There are designated defence practice areas in the offshore marine waters off Ningaloo and the North West Cape. No known defence areas overlap the PAA; however, there was a designated defence practice area in the offshore marine waters off Ningaloo and the North West Cape, within the wider ZoC. A Royal Australian Air Force base located at Learmonth, on North West Cape, lies approximately 350 km south-west of the PAA.

4.5 Values and Sensitivities

The offshore environment of the NWMR contains environmental assets (such as habitat and species) of high value or sensitivity, including Commonwealth offshore waters, as well as the wider regional context including coastal waters and habitats such as the Montebello Islands, Barrow Island, and the Ningaloo World Heritage Area, and the associated resident, temporary or migratory marine life including species such as marine mammals, turtles and birds.

Many sensitive receptor locations are protected as part of Commonwealth and State managed areas (**Figure 4-2**) and have been allocated conservation objectives (IUCN Protected Area Category) based on the Australian IUCN reserve management principles in *Schedule 8 of the EPBC Regulations 2000*.

All planned petroleum activities will take place within the PAA which overlaps one protected area (Ancient coastline at 125 m depth contour KEF). Distances from the PAA to environmentally sensitive areas within the wider region are provided in **Table 4-2**.

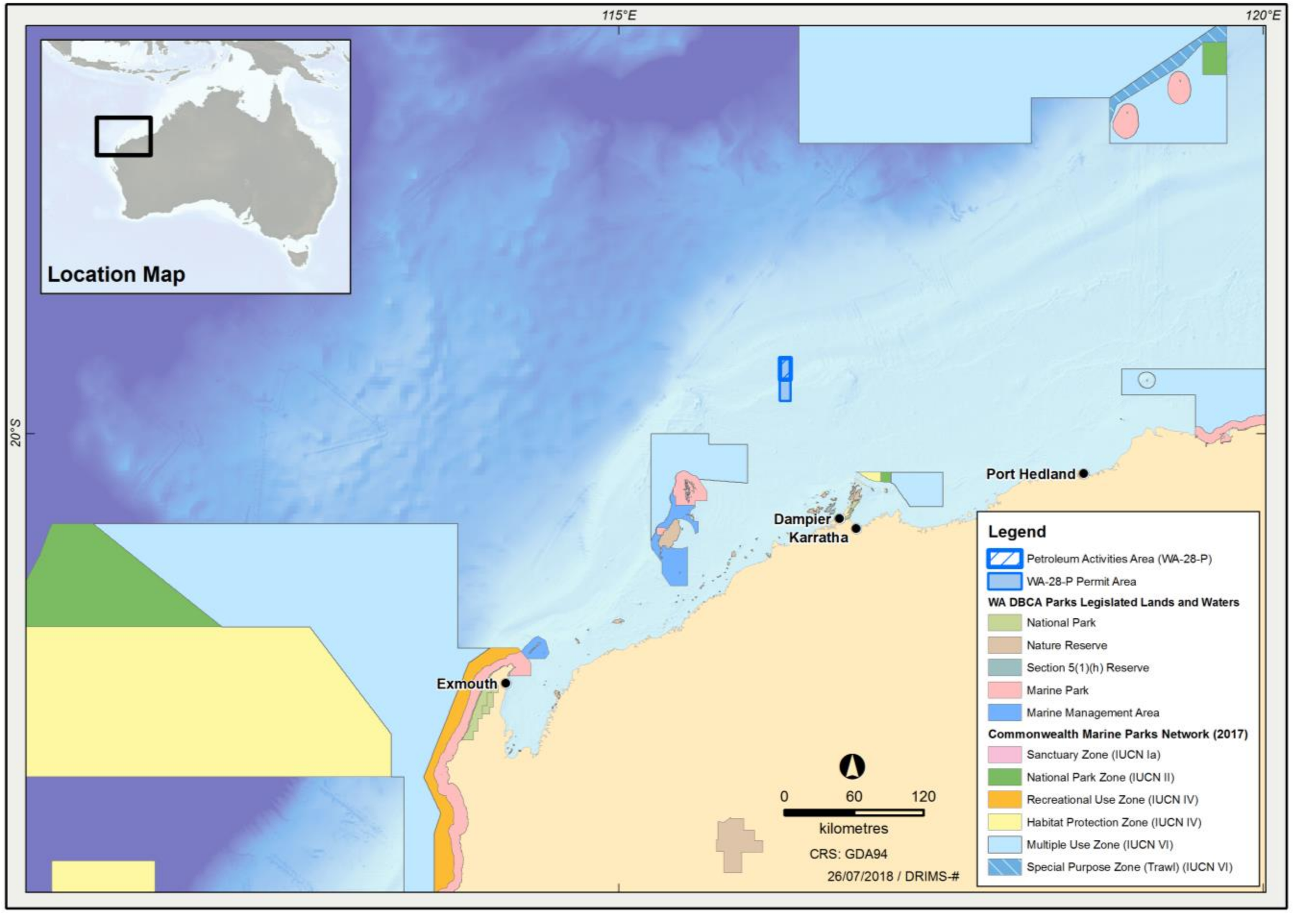

Figure 4-2: Established and proposed Commonwealth and State Marine Protected Areas in relation to the PAA

Table 4-2: Summary of established and proposed Marine Protected Areas (MPAs) and other sensitive locations in the PAA and wider ZoC

	Distance from PAA to Values/Sensitivity boundaries (km)	IUCN Protected Area Category
Australian Marine Parks		
Montebello	48	VI
Dampier	88	II & IV
Gascoyne	300	II, IV & VI
Ningaloo	320	IV
Argo-Rowley Terrace	350	II & VI
Mermaid Reef	438	IA
Shark Bay	651	VI
Carnarvon Canyon	690	IV
Abrolhos	850	II, IV & VI
State Marine Parks and Reserves		
Marine Parks		
Montebello Islands	100	IA, II & IV
Barrow Island	100	IA & VI
Ningaloo	320	IA, II & IV
Rowley Shoals (including Imperieuse Reef)	350	IA, II & IV
Marine Management Areas		
Barrow Island	122	1A & VI
Muiron Islands	302	1A & VI
Fish Habitat Protection Areas		
None identified in PAA or ZoC	-	-
Proposed Marine Park		
None identified in PAA or ZoC	-	-
World Heritage Areas		
Ningaloo	320	N/A
Shark Bay	650	N/A
Key Ecological Features		
Ancient coastline at 125 m depth contour	Overlaps PAA	N/A
Glomar Shoals	23	N/A
Continental Slope Demersal Fish Communities	80	N/A

	Distance from PAA to Values/Sensitivity boundaries (km)	IUCN Protected Area Category
Exmouth Plateau	190	N/A
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	260	N/A
Commonwealth waters adjacent to Ningaloo Reef	310	N/A
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	320	N/A
Canyons linking the Argo Abyssal Plain with the Scott Plateau	635	N/A
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	825	
Western demersal slope and associated fish communities	770	N/A
Western rock lobster	945	N/A

**Conservation objectives for IUCN categories include:*

- *IA: Strict nature reserve – Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.*
- *II: National park – Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for this and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area, and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.*
- *IV: Habitat/species management area – Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.*
- *VI: Protected area with sustainable use of natural resources – Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.*

5. ENVIRONMENTAL IMPACTS AND RISKS

5.1 Risk and Impact Identification and Evaluation

Woodside undertook an environmental risk assessment to identify the potential environmental impacts and risks associated with the Petroleum Activities Program, and the control measures to manage the identified environmental impacts and risks to as low as reasonably practicable (ALARP) and an acceptable level. This risk assessment and evaluation was undertaken using Woodside's Risk Management Framework.

Environmental impacts and risks include those directly and indirectly associated with the Petroleum Activities Program, and includes potential emergency and accidental events. Planned activities have the potential for inherent environmental impacts. An environmental risk is an unplanned event with the potential for impact (termed risk 'consequence').

Herein, potential impact from planned activities are termed 'impacts', and 'risks' are associated with unplanned events with the potential for impact (should the risk be realised), with such impact termed potential 'consequence'.

The key steps of Woodside's Risk Management Framework are shown in **Figure 5-1**. A summary of each step and how it is applied to the proposed Program is provided below.

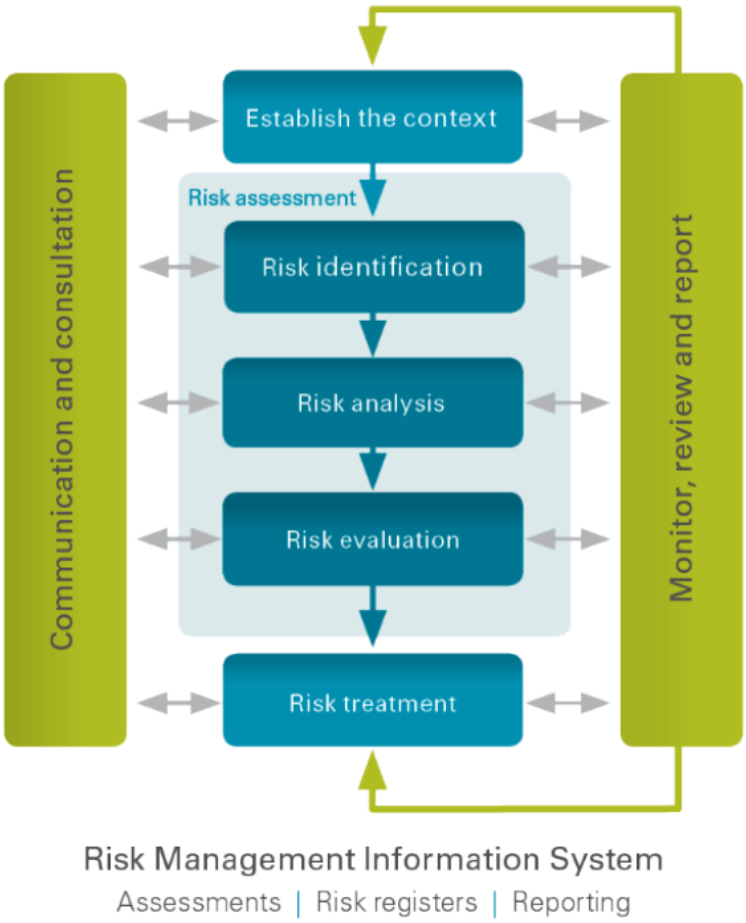

Figure 5-1: Key steps in Woodside's Risk Management Framework

5.1.1 Establish the Context

The objective of a risk assessment is to assess identified risks and apply appropriate control measures to eliminate, control or mitigate the risk to ALARP and to determine if the risk is acceptable.

Hazard identification workshops aligned with NOPSEMA's Hazard Identification Guidance Note were undertaken by multidisciplinary teams made up of relevant personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks and associated impacts were identified and assessed.

5.1.2 Impact and Risk Identification

An Environmental Hazard Identification (ENVID) was undertaken by multidisciplinary teams consisting of relevant engineering and environmental personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks were identified and their potential environmental impacts assessed.

Impacts and risks were identified during the ENVID for both planned (routine and non-routine) activities and unplanned (accidents/incidents/emergency conditions) events.

5.1.3 Risk Analysis

Risk analysis further develops the understanding of a risk by defining the impacts and assessing appropriate controls. Risk analysis considered previous risk assessments for similar activities, review of relevant studies, review of past performance, external stakeholder consultation feedback and review of the existing environment.

The following key steps were undertaken for each identified risk during the risk assessment:

- identification of decision type in accordance with the decision support framework
- identification of appropriate control measures (preventative and mitigation) aligned with the decision type
- Assessment of the risk rating.

5.1.3.1 Decision Support Framework

To support the risk assessment process and Woodside's determination of acceptability, Woodside's HSE risk management procedures include the use of decision support framework based on principles set out in the Guidance on Risk Related Decision Making (Oil and Gas UK, 2014). This concept has been applied during the ENVID or equivalent preceding processes during historical design decisions to determine the level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk is acceptable and ALARP. This is to confirm:

- activities do not pose an unacceptable environmental risk
- appropriate focus is placed on activities where the risk is anticipated to be acceptable and demonstrated to be ALARP
- Appropriate effort is applied to the management of risks based on the uncertainty of the risk, the complexity and risk rating.

The framework provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the risk/impact (referred to as the decision type A, B or C). The decision type is selected based on an informed discussion around the uncertainty of the risk/impact, and documented in ENVID worksheets.

This framework enables Woodside to appropriately understand a risk, determine if the risk or impact is acceptable and can be demonstrated to be ALARP.

Decision Type A

Decision Type A are well understood and established practice, they generally consider recognised good industry practice which is often embodied in legislation, codes and standards and use professional judgment.

Decision Type B

Decision Type B typically involves greater uncertainty and complexity (and can include potential higher order impacts/risks). These risks may deviate from established practice or have some lifecycle implications and therefore require further engineering risk assessment in order to support the decision and ensure that the risk is ALARP. Engineering risk assessment tools may include:

- risk-based tools such as cost based analysis or modelling;
- consequence modelling;
- reliability analysis; and
- company values.

Decision Type C

Decision Type C typically has significant risks related to environmental performance. Such risks or impacts typically involve greater complexity and uncertainty, therefore requiring adoption of the precautionary approach. For risks this may result in significant environmental impact; significant project risk/exposure or may elicit negative stakeholder concerns. For these risks or impacts, in addition to Decision Type A and B tools, company and societal values need to be considered by undertaking broader internal and external stakeholder consultation as part of the assessment process.

5.1.3.2 Identification of Control Measures

Woodside applies a hierarchy of control measures when considering Good Practice and Professional Judgement. The hierarchy of control is applied in order of importance as follows; elimination, substitution, engineering control measures, administrative control measures and mitigation of consequences/impacts.

5.1.3.3 Risk Rating Process

The current risk rating process is undertaken to assign a level of risk to each impact measured in terms of consequence and likelihood. The assigned risk level is the current risk (i.e. risk with controls in place) and is therefore determined following the identification of the decision type and appropriate control measures.

The risk rating process considers the environmental impacts and where applicable, the reputational and brand, legal/compliance and social and cultural impacts of the risk. The risk ratings are assigned using the Woodside Risk Matrix (refer to **Figure 5-2**).

The risk rating process is performed using the following steps:

Select the Consequence Level

Determine the most credible impacts associated with the selected event assuming some controls (prevention and mitigation) have failed (refer to **Table 5-1**). Where more than one impact applies (i.e. environmental and legal/compliance), the consequence level for the highest severity impact is selected.

Table 5-1: Woodside Risk Matrix (environment and social and cultural) consequence descriptions

Environment	Social & Cultural	Consequence Level
Catastrophic, long-term impact (> 50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Catastrophic, long-term impact (>20 years) to a community, social infrastructure or highly valued areas/items of international cultural significance	A
Major, long term impact (10-50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Major, long-term impact (5-20 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	B
Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	Moderate, medium term Impact (2-5 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	C
Minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Minor, short-term impact (1-2 years) to a community or highly valued areas/items of cultural significance	D
Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Slight, short-term impact (<1 year) to a community or areas/items of cultural significance	E
No lasting effect (<1 month). Localised impact not significant to environmental receptors	No lasting effect (<1 month). Localised impact not significant to areas/items of cultural significance	F

Select the Likelihood Level

Select the likelihood level from the description that best fits the chance of the selected consequence actually occurring, assuming reasonable effectiveness of the prevention and mitigation controls (refer to **Table 5-2**).

Table 5-2: Woodside risk matrix likelihood levels

Likelihood Description						
Frequency	1 in 100,000 – 1,000,000 years	1 in 10,000 – 100,000 years	1 in 1,000 – 10,000 years	1 in 100 – 1,000 years	1 in 10-100 years	>1 in 10 years
Experience	**Remote**: Unheard of in the industry	**Highly Unlikely**: Has occurred once or twice in the industry	**Unlikely**: Has occurred many times in the industry but not at Woodside	**Possible**: Has occurred once or twice in Woodside or may possibly occur	**Likely**: Has occurred frequently at Woodside or is likely to occur	**Highly Likely**: Has occurred frequently at the location or is expected to occur
Likelihood Level	0	1	2	3	4	5

Calculate the Risk Rating

A likelihood and risk rating is only applied to environmental risks using the Woodside Risk Matrix. This risk level is used as an input into the risk evaluation process and ultimately for the prioritisation of further risk reduction measures. Once each risk is treated to ALARP, the risk rating articulates the ALARP baseline risk as an output of the ENVID studies.

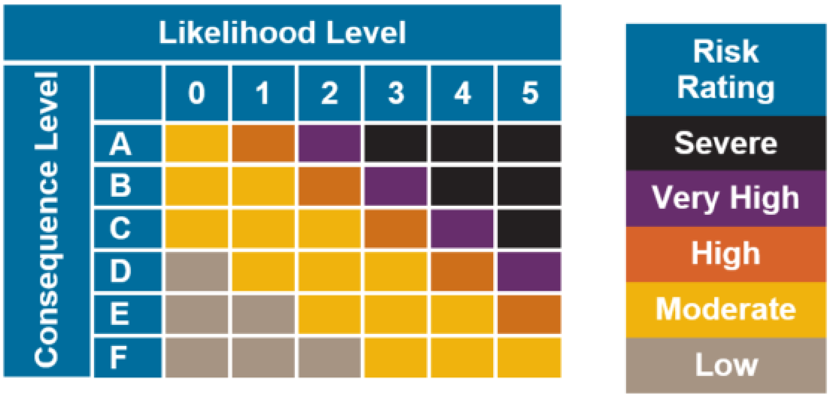

Figure 5-2: Woodside risk matrix: risk level

The ENVID (undertaken in accordance with the methodology described above) identified four sources of environmental risk, comprising three planned, which are all assessed as having a low current risk rating, and one unplanned sources of risk, which is assessed as having a low current risk rating.

The risk analysis and evaluation for the Petroleum Activities Program indicate that all of the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level (refer to **Figure 5-2**: Woodside risk matrix: risk level).

5.1.4 Impact and Risk evaluation

Environmental risks, as opposed to safety risks, cover a wider range of issues, differing species, persistence, reversibility, resilience, cumulative effects and variability in severity. The degree of environmental risk and the corresponding threshold for whether a risk/impact has been has been adapted to include principles of ecological sustainability (given as an objective in the Environment Regulations and defined in the EPBC Act), the Precautionary Principle and the corresponding environmental risk threshold decision-making principles used to determine acceptability.

5.1.4.1 Demonstration of ALARP

Descriptions have been provided below (**Table 5-3**) to articulate how Woodside demonstrates different risks, impacts and Decision Types identified within the EP are ALARP.

Table 5-3: Summary of Woodside's criteria for ALARP demonstration

<table>
<tr><th>Risk</th><th>Impact</th><th>Decision Type</th></tr>
<tr><td>Low and Moderate (below C level consequence)</td><td>Negligible, Slight or Minor</td><td>A</td></tr>
<tr><td colspan="3">Woodside demonstrates these Risks, Impacts and Decision Types are reduced to ALARP:
if controls identified meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines.
further effort towards impact/risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.</td></tr>
<tr><td>High, Very High or Severe (C+ consequence risks)</td><td>Moderate and above</td><td>B and C</td></tr>
<tr><td colspan="3">Woodside demonstrates these higher order Risks, Impacts and Decision Types are reduced to ALARP (where it can be demonstrated using good industry practice and risk based analysis) that;
Legislative requirements, applicable company requirements and industry codes and standards are met;</td></tr>
</table>

- Societal concerns are accounted for; and
- The alternative control measures are grossly disproportionate to the benefit gained.

5.1.4.2 Demonstration of Acceptability

Descriptions have been provided below (**Table 5-4**) to articulate how Woodside demonstrates how different risks, impacts and Decision Types identified within the EP are Acceptable.

Table 5-4: Summary of Woodside's criteria for Acceptability

1. Risk	2. Impact	3. Decision Type
Low and Moderate (below C level consequence)	***Negligible, Slight or Minor***	***A***
Woodside demonstrates these Risks, Impacts and Decision Types are 'Broadly Acceptable', if they meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines. Further effort towards risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe (C+ consequence risks)	***Moderate and above***	***B and C***
Woodside demonstrates these higher order Risks, Impacts and Decision are 'Acceptable if ALARP' can be demonstrated using good industry practice and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained. In undertaking this process for moderate and high current risks, Woodside evaluates the following criteria: Principles of Ecological Sustainable Development (ESD) as defined under the EPBC Act; • Internal context - the proposed controls and consequence/ risk level are consistent with Woodside policies, procedures and standards; • External context – consideration of the environment consequence; • stakeholder acceptability; and • other requirements – the proposed controls and consequence/ risk level are consistent with national and international industry standards, laws and policies. Additionally, Very High and Severe risks require 'Escalated Investigation' and mitigation to reduce the risk to a lower and more acceptable level. If after further investigation the risk remains in the Very High or Severe category, the risk requires appropriate business engagement in accordance with Woodside's Risk Management Procedure to accept the risk. This includes due consideration of regulatory requirements.		

5.2 Hydrocarbon Spill Risk Assessment Methodology

Quantitative hydrocarbon spill modelling was undertaken using a three-dimensional hydrocarbon spill trajectory and weathering model which is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under the influence of changing meteorological and oceanographic forces.

5.2.1 ZoC and Hydrocarbon Contact Thresholds

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental risk, if a credible hydrocarbon spill scenario occurred, solely in terms of delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding hydrocarbon threshold concentrations. All areas where hydrocarbon levels are exceeded are evaluated in the impact assessment. As the weathering of different fates of hydrocarbons (surface, accumulated, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, the locations potentially affected by each fate will differ.

The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the ZoC. A stochastic modelling approach was applied to the quantitative hydrocarbon spill modelling. Stochastic modelling is the combination of a number of individual spill trajectory simulations, modelled under a range of historical metocean data considered seasonally and geographically representative for the scenario modelled. The stochastic results indicate the probability of where hydrocarbon might travel and the time take by the hydrocarbon to reach a given sensitive receptor for all modelled simulations. When considering the ZoC, it is important to understand that the ZoC does not represent the extent of any single spill event, which would be significantly smaller in spatial extent than a ZoC presenting stochastic modelling probabilities.

Surface fate and shoreline accumulation concentrations are expressed as grams per square metre (g/m^2), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb). Hydrocarbon thresholds are presented in the table below (**Table 5-5**) and described in the following subsections.

Table 5-5 Summary of thresholds applied to the quantitative hydrocarbon spill modelling results

Surface Hydrocarbon (g/m^2)	Entrained hydrocarbon (ppb)	Dissolved aromatic hydrocarbon (ppb)
10	500	500

5.2.2 Surface Hydrocarbon Threshold Concentrations

The spill modelling outputs defined the ZoC for surface hydrocarbon spills (contact on surface waters) using the ≥10 g/m^2) based on the relationship between film thickness and appearance (Bonn Agreement, 2015) (**Table 5-6**). This threshold concentration expressed in terms of g/m^2 is geared towards informing potential oiling impacts for wildlife groups and habitats that may break through the surface slick from the water or the air (for example: emergent reefs, vegetation in the littoral zone and air-breathing marine reptiles, cetaceans, seabirds and migratory shorebirds).

Thresholds for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at approximately 10–25 g/m^2 (French *et al*., 1999; Koops *et al*., 2004; NOAA, 1996). Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening of contaminated feathers or the loss of the thermal protection of their feathers. The 10 g/m^2 threshold is the reported level of oiling to instigate impacts to seabirds and is also applied to other wildlife though it is recognised that 'unfurred' animals where hydrocarbon adherence is less, may be less vulnerable. 'Oiling' at this threshold is taken to be of a magnitude that can cause a response to the most vulnerable wildlife such as seabirds. Due to weathering processes, surface hydrocarbons will have a lower toxicity due to change in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact.

Table 5-6: The Bonn Agreement oil appearance code

Appearance (following Bonn visibility descriptors)	Mass per area (g/m^2)	Thickness (μm)	Volume per area (L/km^2)
Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
Dull metallic colours	5 to 50	5 to 50	5,000 to 50,000
Rainbow sheen	0.30 to 5.00	0.30 to 5.00	300 to 5,000
Silver sheen	0.04 to 0.30	0.04 to 0.30	40 to 300

5.2.3 Dissolved Aromatic Hydrocarbon Threshold Concentrations

Woodside has undertaken ecotoxological testing on a number of condensates obtained during Woodside's exploration and production activities. The closest condensate to GDA 01/02 composite and GDA condensates condensate (i.e. the Petroleum Activity Program Representative Hydrocarbon), that Woodside has ecotoxicology test results for is Browse Basin (Calliance, Brecknock and Torosa gas fields) unweathered condensate. Browse condensate presents a slightly lower level of volatiles (which are typically the more toxic components of the hydrocarbon), than GDA 01/02 composite and GDA condensates while the aromatics component (also more toxic compounds) for the two are fairly similar. **Table** 5-7 compares characteristics of GDA 01/02 composite, GDA condensate and Browse condensate. Browse condensate ecotox data is considered to be an applicable surrogate for GDA 01/02 Composite and GDA Condensates.

Table 5-7: Comparison of GDA 01/02 Composite, GDA Condensate and Browse Condensate characteristics

Hydrocarbon Type	Initial Density (g/cm^3)	Viscosity (cP @ 20˚C)	Component BP (˚C)	Volatiles <180˚C	Semi volatiles 180–265˚C	Low Volatility (%) 265–380˚C	Residual (%) >380˚C	Aromatic (%) of whole oil <380°C BP
				Non-Persistent			Persistent	
GDA 01/02 Composite Sample	0.7723	< 5% (0.3% wt)	1.110 cP @ 20˚C)	% of total	61.3	23.6	12.7	2.4
GDA Condensate	0.7449	<5 % (0.2% wt)	1.61 cP @ 15˚C	% of total	71.6	19.8	7.0	1.6
Browse Condensate	0.780	<5 % wt	1.092 cP @ 20˚C)	% of total	57.0	21.0	8.0	14.0

Table 5-8 shows the range of the no observed effect concentration (NOEC) total petroleum hydrocarbons (TPH) concentrations for each of the condensate water accomodated fractions (WAFs) tested. The range represents the variability in results of the ecotoxicity results due to the different composition of each condensate.

Table 5-8: Summary of total recoverable hydrocarbons NOECs for key life-histories of different biota based on toxicity tests for WAF of Browse Basin condensate

Biota and Life Stage	Exposure duration	NOEC – TRH concentration of unweathered Browse condensate showing no direct biological effect (ppb)
Sea urchin fertilisation	1 hour	3670–15590
Sea urchin larval development	72 hours	8040–32360
Rock oyster larval development	48 hours	15820–32360
Macro-algal germination	72 hours	39490–77310
Micro-algal growth test	72 hours	24270–39490
Larval fish imbalance test	96 hours	1280–3670
Tiger prawn acute toxicity test	96 hours	1280–2030

Source: ESA 2009

The ecotox testing focuses on the TPH concentration of the WAF of the hydrocarbon and includes the carbon chains C6 to C36. Typically, C4 to C10 compounds are volatile (BP <180 °C), C11 to C15 compounds are semi-volatile (BP 180–265 °C), C16 to C20 compounds have low volatility (265-380 °C) and C21 compounds and above are residual (BP >380 °C).

The purpose of the threshold is to inform the assessment of the potential for toxicity impacts to sensitive marine biota. The ecotoxicity tests were undertaken on a broad range of taxa of ecological relevance for which accepted standard test protocols are well established. These ecotoxicology tests are focused on the early life stages of test organisms, when organisms are typically at their most sensitive. The ecotoxicology tests were conducted on six mainly tropical-subtropical species representatives from six major taxonomic groups.

The laboratory-based ecotoxicology tests used a range of WAF concentrations to expose the different test organisms. For each ecotoxicity test, samples of the WAF were analysed to determine the TPH concentration of the solution.

Table 5-8 presents the results of NOECs for the condensate WAFs tested. The range of NOECs for the organisms tested ranged from 1280 ppb to 77,310 ppb. These results are consistent with other condensate ecotoxological testing undertaken by Woodside. Based on these ecotoxicology tests, a dissolved aromatic hydrocarbon threshold of 500 ppb has been adopted. This 500 ppb threshold is significantly less than the lowest NOEC for the most sensitive organism tested. Therefore, it is considered that the 500 ppb dissolved aromatic threshold is a conservative threshold to apply to the GDA 01/02 composite and GDA condensate analogues, which has been used in hydrocarbon modelling.

5.2.4 Entrained Hydrocarbon Threshold Concentrations

The spill modelling outputs are used to define the ZoC by defining the spatial variability of entrained hydrocarbons above a set concentration threshold contacting sensitive receptors (expressed in ppb).

Entrained hydrocarbons present a number of possible mechanisms for toxic exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, hence have the potential for generating elevated concentrations of dissolved aromatic hydrocarbons (e.g. if mixed by breaking waves against a shoreline). Physical and chemical effects of the entrained hydrocarbon droplets have also been demonstrated through direct contact with organisms, for example through physical coating of gills and body surfaces, and accidental ingestion (National Research Council, 2005).

The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for WAF of oil hydrocarbons (**Table 5-8**). However, it is likely these data specific to dissolved oil hydrocarbon represents a worst-case scenario. This is owing to the fact that entrained oil hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved hydrocarbons. It is therefore expected that the entrained threshold concentration of 500 ppb will represent a potential impact substantially lower than the NOEC concentrations presented in **Table 5-8**.

5.2.5 Accumulated Hydrocarbon Threshold Concentrations

Owens and Sergy (1994) define accumulated hydrocarbon <100 g/m^2 to have an appearance of a stain on shorelines. French-McCay (2009) defines accumulated hydrocarbons ≥100 g/m^2 to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat.

6. ENVIRONMENTAL RISK AND IMPACTS SUMMARY

Table 6-1 presents a summary of the sources of impact/risk, analysis and evaluation for the Petroleum Activities program.

The risks identified during the ENVID (including decision type, current risk level, acceptability of risk and tools used in the demonstration of acceptability and ALARP) have been divided into two broad categories:

- planned (routine and non-routine) activities; and
- unplanned events (accidents, incidents or emergency situations).

Within these categories, impact assessment groupings are based on stressor type e.g. emissions, physical presence etc. In all cases the worst credible consequence was assumed.

The analysis and evaluation for the Petroleum Activities Program indicate that all of the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level.

A detailed description of credible environmental risks and potential impacts together with a summary of control measures have been presented in **Appendix B**.

Table 6-1: Environmental Risk and Impacts Register Summary

Aspect	EP Section	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Consequence	Residual Impact Level (ALARP controls in place	Acceptability of Impact
Physical Presence: Interference with or Displacement of Third Party Vessels	5.6.1	Displacement of other users – proximity of MODU, ISVs and support vessels causing interference with or displacement to third party vessels (commercial fishing, recreational fishing and commercial shipping).	Potential isolated social impact potentially resulting from interference with other sea users (e.g. commercial and recreational fishing, and shipping).	E	Social and Cultural – No lasting effect (< 1 month). Localised impact not significant to areas/items of cultural significance.	Broadly acceptable
		Wellhead left in-situ causing interference with or displacement to third party vessels (commercial shipping, and commercial/recreational fishing).		E	Social and Cultural – No lasting effect (< 1 month). Localised impact not significant to areas/items of cultural significance.	Broadly acceptable
Physical Presence: Disturbance to Benthic Habitat from MODU Anchoring, Drilling Operations and ROV Operation	5.6.2	Disturbance to seabed from: • Drilling operations • Installation of conductor with CAN • ROV operations • Disturbance to seabed from wellhead remaining in-situ (if required).	Localised modification of seabed habitat within Operational Area with potential for impacts to water quality and benthic communities of no lasting effect.	F	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
		Disturbance to seabed from MODU holding station (MODU mooring, including anchor holding testing).		E		Broadly acceptable
Routine Acoustic Emissions: Generation of Noise from VSP	5.6.3	Generation of acoustic signals from VSP.	Temporary and minor disruption (e.g. avoidance) to fauna, including protected species.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. protected species).	Broadly acceptable
Routine Acoustic Emission: Generation of Noise from Activity Vessels, MODU, Positioning Equipment and Helicopter Transfers	5.6.4	Generation of acoustic signals from: • Drilling, support vessels and ISV during normal operations • Dynamic positioning systems of DP ISV. Generation of atmospheric noise from helicopter transfers.	Temporary and minor disruption (e.g. avoidance or attraction) to fauna, including protected species.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. protected species).	Broadly acceptable
Routine and Non-routine Discharges to the Marine Environment: MODU and Project Vessels	5.6.5	Routine discharges of: • Sewage, grey water and putrescible wastes to marine environment from MODU, ISV and support vessels • Deck and bilge water to marine environment from MODU, ISV and support vessels • Cooling water or brine to the marine environment from MODU, ISV and support vessels	Localised and temporary effects to water quality and marine biota in offshore waters.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. water quality).	Broadly acceptable

Aspect	EP Section	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Consequence	Residual Impact Level (ALARP controls in place	Acceptability of Impact
Routine and Non-routine Discharges to the Marine Environment: Drill Cuttings and Drilling Fluids (WBM and NWBM)	5.6.6	Routine discharges of: • WBM drill cuttings to the seabed and the marine environment • NWBM drill cuttings to the seabed and the marine environment • Drilling muds (WBM) to the seabed and the marine environment • Well clean-up and DST fluids Non-routine discharge of wash water from mud pits and vessel tank wash fluids.	Localised burial and smothering of benthic habitats. Localised and temporary slight effects to water quality (e.g. turbidity increase) and marine biota in offshore waters.	E	Environment – slight, short term local impact (<1 year) on species, habitat (But not affecting ecosystems function), physical or biological attributes.	Broadly acceptable
		Discharge of well annular fluids from temporarily abandoned well.		F	Environment – No lasting effect (<1 month) localised impact not significant.	Broadly acceptable
Routine and Non-routine Discharges to the Marine Environment: Cementing, Subsea Fluids and Unused Bulk Products	5.6.7	Routine discharge of cement, cement cuttings, cementing fluids, subsea fluids (e.g. BOP control fluids and well suspension fluids) and other down-well products to the seabed and the marine environment.	Localised burial and smothering of benthic habitats. Localised and temporary slight effects to water quality (e.g. turbidity increase) and marine biota in offshore waters.	E	Environment – slight, short term local impact (<1 year) on species, habitat (But not affecting ecosystems function), physical or biological attributes.	Broadly acceptable
Routine Atmospheric Emissions: Fuel Combustion, Flaring, Incineration and Venting	5.6.8	Atmospheric emissions from: • Internal combustion engines and incinerators on MODU, ISV and support vessels • Flaring during DST • Unplanned venting gas.	Reduced local air quality from atmospheric emissions.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. air quality)	Broadly acceptable
Routine Light Emissions: External Lighting on MODU, ISA and Support Vessels	5.6.9	External light emissions on-board MODU, ISV and project vessels.	Disturbance to marine fauna, particularly seabirds, marine turtles and fish.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. species)	Broadly acceptable

Aspect	EP Section	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Risk Rating				Acceptability of Risk
				Consequence	Potential Consequence level of impact[2]	Likelihood	Current Risk Rating	
Unplanned Activities (Accidents / Incidents)								
Accidental Hydrocarbon Release: Loss of Well Integrity	5.7.2	Loss of hydrocarbons to marine environment due to loss of well integrity.	Short to medium term impacts to the offshore marine environment. Long-term impacts to sensitive nearshore areas of offshore islands (e.g. Montebello/Barrow/Lowendal Island Group) and coastal shorelines (e.g. Ningaloo Coast). Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users (e.g. fishing and shipping).	B	Environment – Major, long-term impact (10-50 years) on highly valued ecosystems, species, habitat, physical or biological attributes. Reputation/brand – National concern and/or international interest. Medium to long-term impact (5-20 years) to reputation and brand. Venture and/or asset operations restricted.	2	H	Acceptable if ALARP
Accidental Hydrocarbon Release: Vessel Collision	5.7.3	Loss of hydrocarbons to marine environment due to a vessel collision (e.g. support vessels or other marine users).	Minor and temporary disruption to marine fauna, including protected species. Minor and/or temporary impacts to water quality.	D	Environment – Minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	1	M	Broadly Acceptable
Loss of hydrocarbons to marine environment from bunkering/refuelling	5.7.4	Temporary disruption to marine fauna, including protected species. Temporary and localised impacts to water quality.	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. air quality).	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. air quality).	2	L	Broadly Acceptable
Unplanned Discharges: Drilling Fluids	5.7.5	Accidental discharge of drilling fluids (WBM/NWBM/base oil) to marine environment due to failure of slip joint packers, bulk transfer hose/fitting, emergency disconnect system or from routine MODU operations.	Slight and temporary disruption to marine fauna, including protected species. Slight and/or temporary impacts to water quality.	F	Environment – slight, short-term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical and biological attributes.	1	L	Broadly Acceptable
Unplanned Discharges: Deck, Subsea Spills from ROV and spills from DST	5.7.6	Accidental discharge to the ocean of other hydrocarbons/chemicals from MODU or support vessel deck activities and equipment (e.g. cranes) including helicopter refuelling and subsea ROV hydraulic leaks.	Slight and temporary disruption to marine fauna, including protected species. Slight and/or temporary impacts to water quality.	E	Environment – slight, short-term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly Acceptable
		Accidental discharge to the ocean of hydrocarbons during DST if the flare is extinguished.	Slight and temporary disruption to marine fauna, including protected species. Slight and/or temporary impacts to water quality.	E	Environment – slight, short-term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly Acceptable

Aspect	EP Section	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Risk Rating				Acceptability of Risk
				Consequence	Potential Consequence level of impact[2]	Likelihood	Current Risk Rating	
Unplanned Discharges: Loss of Solid Hazardous and Non-hazardous Wastes/Equipment	5.7.7	Accidental loss of hazardous or non-hazardous wastes/equipment to the marine environment (excludes sewage, grey water, putrescible waste and bilge water).	Localised and temporary impacts to water quality.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. water quality)	2	L	Broadly Acceptable
Physical Presence: Vessel Collision with Marine Fauna	5.7.8	Accidental collision between project vessels and threatened and migratory whale species.	Slight and temporary disruption to marine fauna, including protected species.	E	Environment – slight, short-term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly Acceptable
Physical Presence: Loss of Station Keeping and Failure of Mooring Integrity	5.7.9	Failure of mooring integrity leading to seabed disturbance.	Localised disturbance of benthic habitats.	E	Environment – slight, short-term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly Acceptable
		Loss of station keeping due to failure of mooring integrity resulting in anchor drag & loss of containment from existing subsea pipelines.	Localised disturbance of benthic habitats.	C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Broadly Acceptable
Physical Presence: Disturbance to Seabed from Dropped Objects	5.7.10	Dropped objects resulting in seabed disturbance.	Localised short-term damage of benthic subsea habitats in the immediate location of the dropped objects.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. benthic habitats).	2	L	Broadly Acceptable
Physical Presence: Accidental Introduction of Invasive Marine Species	5.7.11	Introduction of invasive marine species (IMS).	Localised and temporary introduction of IMS into the Permit Area, which will not survive.	F	Environment – No lasting effect (<1 month) localised impact not significant to environmental receptors (e.g. benthic habitats).	0	L	Broadly Acceptable

7. ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE

The Petroleum Activities Program will be managed in compliance with the WA-28-P Drilling EP accepted by NOPSEMA under the Environment Regulations, other relevant environmental legislation and Woodside's Management System (e.g. Woodside Environment Policy).

The objective of the EP is to identify, mitigate and manage potentially adverse environmental impacts associated with the Petroleum Activities Program, during both planned and unplanned operations, to ALARP and an acceptable level.

For each environmental aspect (risk), and associated environmental impacts (identified and assessed in the Environmental Risk Assessment of the EP) a specific environmental performance outcome, environmental performance standards and measurement criteria have been developed. The performance standards are control measures (available in **Appendix A**) that will be implemented (consistent with the performance standards) to achieve the environmental performance outcomes. The specific measurement criteria provide the evidence base to demonstrate that the performance standards (control measures) and outcomes are achieved.

The implementation strategy detailed in the WA-28-P Drilling EP identifies the roles/responsibilities and training/competency requirements for all personnel (Woodside and its contractors) in relation to implementing controls, managing non-conformance, emergency response and meeting monitoring, auditing, and reporting requirements during the activity.

The tools and systems collect, as a minimum, the data (evidence) referred to in the measurement criteria. The collection of this data (and assessment against the measurement criteria) forms part of the permanent record of compliance maintained by Woodside and the basis for demonstrating that the environmental performance outcomes and standards are met, which is then summarised in a series of routine reporting documents.

Monitoring of environmental performance is undertaken as part of the following:

- Annual Environmental Compliance and Performance Reports which are submitted to NOPSEMA to assess and confirm compliance with the accepted environmental performance objectives, standards and measurement criteria outlined in the EP
- Activity based inspections undertaken by Woodside's environment function to review compliance against the WA-28-P Drilling EP, verify effectiveness of the EP implementation strategy and to review environmental performance
- Environmental performance is also monitored daily via daily progress reports during the proposed Program; and
- Senior management regularly monitors and reviews environmental performance via a monthly report which detail environmental performance and compliance with Woodside standards.

Woodside employees and Contractors are required to report all environmental incidents and non-conformance with environmental performance outcomes and standards in the EP. Incidents will be reported using an Incident and Hazard Report Form, which includes details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence. An internal computerised database is used for the recording and reporting of these incidents. Incident corrective actions are monitored to ensure they are closed out in a timely manner.

7.1 Environment Plan Revisions and Management of Change

Revision of the WA-28-P Drilling EP will be undertaken in accordance with the requirements outlined in Regulations 17, Regulation 18 and Regulation 19 of the Environment Regulations. Woodside will submit a proposed revision of the Wa-28-P Drilling EP to NOPSEMA including as a result of the following:

- When any significant modification or new stage of the activity that is not provided for in the EP is proposed
- Before, or as soon as practicable after, the occurrence of any significant new or significant increase in environmental risk or impact not provided for in the EP
- At least 14 days before the end of each period of five years commencing on the day in which the original and subsequent revisions of the EP is accepted under Regulation 11 of the Environment Regulations; and
- As requested by NOPSEMA.

Management of changes relevant to the Drilling EP, concerning the scope of the activity description, changes in understanding of the environment, including all current advice on species protected under EPBC Act and potential new advice from external stakeholders, will be managed in accordance with internal procedures for management of change. These provide guidance on the Environment Regulations that may trigger a revision and resubmission of the Drilling EP to NOPSEMA. They also provide guidance on what constitutes a significant new risk or increase in risk. A risk assessment will be conducted in accordance with Woodside's Environmental Risk Management Methodology to determine the significance of any potential new environmental impacts or risks not provided for in the Drilling EP. Risk assessment outcomes are reviewed in compliance with Regulation 17 of the Environment Regulations.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a revision, under Regulation 17 of the Environment Regulations, will be considered a 'minor revision'. Minor administrative changes to the Drilling EP, where an assessment of the environmental risks and impacts is not required (e.g. document references, phone numbers, etc.), will also be considered a 'minor revision'. Minor revisions and administrative changes as defined above will be made to the Drilling EP using Woodside's document control process. Minor revisions will be tracked and incorporated during scheduled internal reviews.

8. OIL POLLUTION EMERGENCY RESPONSE ARRANGEMENTS

Woodside's OPEP for the Petroleum Activities Program has the following components:

- Oil Pollution Emergency Arrangements (Australia);
- WA-28-P Drilling Oil Pollution Frist Strike Plan; and
- Oil Spill Preparedness and Response Mitigation Assessment for WA-28-P Drilling Environment Plan.

8.1 Woodside Oil Pollution Emergency Arrangements (Australia)

This document outlines the emergency and crisis management incident command structure (ICS) and Woodside's response arrangements to competently respond to and escalate a hydrocarbon spill event. The document interfaces externally with Commonwealth, State and industry response plans and internally with Woodside's ICS.

Woodside's Oil Pollution Emergency Arrangements (Australia) details the following support arrangements:

- Access to MODU to drill intervention well via Memorandum of Understanding (MoU) with other industry participants;
- Master services agreement with Australian Marine Oil Spill Centre (AMOSC) for the supply of experienced personnel and equipment;
- Access to Wild Well Control's capping stack, SFRT equipment and experienced personnel for the rapid deployment and installation of a capping stack, where feasible (may require well intervention prior to deployment);
- Other support services such as 24/7 hydrocarbon spill trajectory modelling and satellite monitoring services as well as aerial, marine, logistics and waste management support; and
- Mutual Aid Agreements with other oil and gas operators in the region for the provision of assistance in a hydrocarbon spill response.

8.2 WA-28-P Drilling Oil Pollution First Strike Plan

The WA-28-P Oil Pollution First Strike Plan is an activity-specific document which provides details on the tasks required to mobilise a first strike response for the first 24 hours of a hydrocarbon spill event. These tasks include key response actions and regulatory notifications. The intent of the document is to provide immediate oil spill response guidance to the Incident Management Team until a full Incident Action Plan specific to the oil spill event is developed.

The activity vessels will have Ship Oil Pollution Emergency Plans (SOPEPs) in accordance with the requirements of International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex I. These plans outline responsibilities, specify procedures and identify resources available in the event of a hydrocarbon or chemical spill from vessel activities. The WA-28-P Drilling Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs.

Woodside's oil spill arrangements are tested by conducting periodic exercises. These exercises are conducted to test the response arrangements outlined in the WA-28-P Drilling Oil Pollution First Strike Plan and to ensure that personnel are familiar with spill response procedures, in particular, individual roles and responsibilities and reporting requirements.

8.3 Oil Spill Preparedness and Response Mitigation Assessment

Woodside has developed an oil spill preparedness and response position in order to demonstrate that risks and impacts associated with loss of hydrocarbons from the Petroleum Activities Program would be mitigated and managed to ALARP and would be of an acceptable level.

The following oil spill response strategies were evaluated and subsequently pre-selected for a significant oil spill event (level 2 or 3 under the National Plan) from the Petroleum Activities Program:

- Monitor and Evaluate (Operational Monitoring) – Operational Monitoring commences immediately following a spill and includes the gathering and evaluation of data to inform the oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. Woodside would implement the following operational monitoring plans to satisfy the requirements of this strategy. The following operational monitoring programs are available for implementation:
    - Predictive modelling of hydrocarbons to assess resources at risk;
    - Surveillance and reconnaissance to detect hydrocarbons and resources at risk;
    - Monitoring of hydrocarbon presence, properties, behaviour and weathering in water;
    - Pre-emptive assessment of sensitive receptors at risk; and
    - Monitoring of contaminated resources and the effectiveness of response and clean-up operations.
- The following response strategies may be applied based on the outcomes of implemented Operational Monitoring programs:
    - Containment and recovery - The aim of this response strategy is to reduce damage to sensitive resources by the physical containment and mechanical removal of hydrocarbons from the marine environment.
    - Source control - A loss of well control is the identified worst case spill scenario. Woodside's primary mitigation strategy is to minimise the volume of hydrocarbons released. Woodside plans to deploy the following response options specific to a loss of well control event:
        - Well intervention - BOP intervention / ROV survey, Top kill / mud kill;
        - SFRT - Debris clearance/removal, Subsea dispersant injection;
        - Capping stack deployment; and/or
        - Relief well drilling.
    - Shoreline clean-up - Shoreline clean-up is undertaken when residual hydrocarbons not collected through previously described response strategies make contact with shorelines. The timing, location, and extent of shoreline clean-up can vary from one scenario to another, depending on the hydrocarbon type, shoreline type and access, degree of oiling and area oiled. A shoreline clean-up can limit injury to wildlife, prevent or reduce remobilisation of hydrocarbons in the tidal zone, facilitate habitat recovery and meet societal expectations.
    - Wildlife response - An oiled wildlife response would be undertaken in accordance with Woodside's Health, Safety, Environment and Quality Policy and values and recognition of societal expectations. The response would involve reconnaissance from vessels, aircraft and shoreline surveys, the capture, transport, rehabilitation and release of oiled wildlife.
    - Scientific monitoring - A scientific monitoring program (SMP) would be activated following a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and

socio-economic) for the entire predicted ZoC and in particular, the identified Pre-emptive Baseline Areas (PBAs) in the event of a loss of well control from the PAP drilling activities (refer to response planning assumptions). The SMP would be informed by the operational monitoring programs, but differs from the operational monitoring program in being a long-term program independent of, and not directing, the operational oil spill response. Key objectives of the Woodside oil spill scientific monitoring program are:

- Assess the extent, severity and persistence of the environmental impacts from the spill event; and
- Monitor subsequent recovery of impacted key species, habitats and ecosystems.

- Waste management - Waste management is considered a support strategy to the response strategies examined above.

9. CONSULTATION

In support of the Drilling EP, Woodside conducted a stakeholder assessment and engaged with relevant stakeholders to inform decision-making and planning for this petroleum activity in accordance with the requirements of Regulation 11A and 14(9) of the Environment Regulations.

Woodside conducted an assessment to identify relevant stakeholders, based on the location of the Drilling and potential environmental and social impacts. A consultation fact sheet was sent to all stakeholders identified through the stakeholder assessment process prior to lodgement of the Drilling EP with NOPSEMA for assessment and acceptance. Woodside provided information about the Petroleum Activities Program to the relevant stakeholders listed in **Table 9-1**. Woodside considers relevant stakeholders for routine operations as those that undertake normal business or lifestyle activities in the vicinity of the existing Petroleum Activities Program (or their nominated representative) or have a State or Commonwealth regulatory role.

Table 9-1: Relevant Stakeholder Identified for the Petroleum Activities Program

Organisation	Relevance
Department of Industry, Innovation and Science	Department of relevant Commonwealth Minister
Department of Mines, Industry Regulation and Safety *(formerly Department of Mines and Petroleum)*	Department of relevant State Minister
Australian Maritime Authority	Maritime safety
Australian Hydrographic Office	Maritime safety
Department of Primary Industries and Regional Development *(formerly Department of Fisheries (WA))*	Fisheries management
Commonwealth Fisheries Association	Commercial fisheries (Commonwealth)
Western Australian Fishing Industry Council	Commercial fisheries (State)
Department of Defence	Defence estate management
Department of Transport	Hydrocarbon spill preparedness (Western Australian waters)
Department of the Environment and Energy	Responsible for Sea Dumping Act implementation
Western Australian fisheries	Commercial fisheries – State • Pearl Oyster • Gascoyne Demersal Scalefish • West Coast Deep Sea Crustacean • Pilbara Fish Trawl • Pilbara Trap • Onslow Prawn • Mackerel Fishery • South West Coast Salmon • Abalone • Marine Aquarium Fish • Specimen Shell

Consultation activities conducted for the proposed EP builds upon Woodside's extensive and ongoing stakeholder consultation for its offshore petroleum activities in the region.

Woodside consultation arrangements typically provide stakeholders up to 30 days (unless otherwise agreed) to review and respond to proposed activities where stakeholders are potentially affected. Woodside considers this consultation period an adequate timeframe in which stakeholders can assess potential consequences of the proposed activities and provide feedback to Woodside as is commensurate with government public review records.

9.1 Ongoing Consultation

Woodside continue to engage and consult with relevant stakeholders throughout the Petroleum Activities Program by implementing its established approach to stakeholder engagement that includes;

- Direct stakeholder and community engagement providing advice to community stakeholders on progress in execution of activities;
- Provision of updated activity factsheets prior to the commencement of activities; and
- Toll free number provided on activity factsheets.

Woodside will continue to accept feedback from all stakeholders throughout the duration of the accepted Drilling EP. Stakeholder feedback should be made to the nominated liaison person.

Feedback received through community engagement and consultation will be captured in Woodside's stakeholder database and actioned where appropriate through the Petroleum Activities Program Project Manager. Implementation of ongoing engagement and consultation activities for the Petroleum Activities Program will be undertaken by Woodside Corporate Affairs consistent with Woodside's External Stakeholder Engagement Operating Standard.

9.2 Non-Routine Events

Woodside recognises that the relevance of stakeholders identified in the EP to the activity may change in the occurrence of a non-routine event or emergency. Woodside also acknowledges that other stakeholders not identified in the EP may be affected.

Stakeholder groups include:

- Government Ministers
- Government agencies
- Local governments, including representation local communities
- Emergency response organisations
- Border protection and defence
- Fisheries
- Charter boat operators
- Marine and terrestrial tourism operators
- Other petroleum operators
- Other industry
- Development commissions and industry associations
- Aboriginal claimant groups
- Community representative organisations
- Non-Government Organisations.

10. TITLEHOLDER NOMINATED LIAISON PERSON

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11. ABBREVIATIONS

Term	Description / Definition
µm	µm
AFMA	Australian Fisheries Management Authority
AHS	Australian Hydrographic Service
AHV	Ancho Handling Vessels
ALARP	As Low As Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
APPEA	Australian Petroleum Production & Exploration Association
BIA	Biologically Important Area
BOP	Blow-out Preventer
CAN	Conductor Anchor Node
CFA	Commonwealth Fisheries Association
cm	Centimetre
CPF	Central Processing Facility
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Department of Environment, Water, Heritage and the Arts
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DST	Drill Stem Testing
EDS	Emergency Disconnect Sequence
ENVID	Environmental hazard Identification
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*.
ESD	Ecologically Sustainable Development
FLNG	Floating liquefied natural gas
FPSO	Floating Production, Storage and Offtake vessel
g/m^2	Grams per square metre
H&S	Health and Safety
HQ	Hazard Quotient
ICS	Incident Command Structure
IFAW	International Fund for Animal Welfare
ISV	Installation support vessel
ITF	Indonesian Throughflow
IUCN	International Union for Conservation of Nature
KEF	Key Ecological Feature

km	Kilometre
kPa	Kilopascal
L	Litres
L/km^2	Litres per square kilometre
LAO	Linear Alpha Olefin
LARS	Launch and Recovery Systems
LAT	Lowest Astronomical Tide
LOC	Loss of containment
m	Metres
m^3	Cubic metres
MNES	Matters of National Environmental Significance
MODU	Mobile Offshore Drilling Unit
MoU	Memorandum of Understanding
MPA	Marine Protected Areas
NOEC	No-observed-effect concentrations
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NRC	North Rankin Complex
NTU	Nephelometric Turbidity Units
NWBM	Non-water Based Muds
NWMR	North-west Marine Region
NWS	Northwest Shelf Province
OCNS	Offshore Chemical Notification Scheme
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act*
OSPAR	Oslo and Paris Commission for the Convention for the Protection of the Marine Environment of the North-East Atlantic
PAA	Petroleum Activities Area
PIC	Person In Charge
PLONOR	Pose Little or No. Risk to the Environment
ppb	Parts Per Billion
PTW	Permit to Work
RMR	Riserless mud recovery
RO	Reverse Osmosis
ROV	Remotely Operated Vehicle
SCE	Solids Control Equipment
SFRT	Subsea First Response Toolkit
SMP	Scientific Monitoring Program

SOPEP	Ship Oil Pollution Emergency Plans
SVP	Senior Vice President
SWMR	South-west Marine Region
TD	Total Depth
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UK	United Kingdom
VP	Vice President
VSP	Vertical Seismic Profiling
WA	Western Australia
WA DMP	Department of Mines and Petroleum WA DMP
WAF	Water Accommodated Fractions
WAFIC	Western Australian Fishing Industry Council
WBM	Water Based Mud
WOMP	Well Operations Management Plan
Woodside	Woodside Burrup Pty Ltd (note references to Woodside may also be references to Woodside Petroleum Ltd or its applicable subsidiaries.
ZoC	Zone of Consequence

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APPENDIX A: ENVIRONMENTAL IMPACTS AND RISKS

PLANNED ACTIVITIES (ROUTINE AND NON-ROUTINE)

Physical Presence: Interference with or Displacement of Third Party Vessels

Impacts and Risks Evaluation Summary

Source of Impact	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Displacement of other users - proximity of MODU, ISVs and support vessels causing interference with or displacement to third party vessels (commercial fishing, recreational fishing and commercial shipping).							X	A	E	-	-	LCS GP PJ	Broadly acceptable	EPO 1, 2 & 3
Wellhead left in-situ causing interference with or displacement to third party vessels (commercial shipping, and commercial/ recreational fishing).							X	A	E	-	-	LCS GP PJ	Broadly acceptable	EPO 1, 3 & 4

Environmental Value Potentially Impacted: Soil and Groundwater to Socio-Economic. Evaluation: Decision Type to Outcome.

Description of Source of Impact

In order to drill each well (up to six wells), the MODU will be present for approximately 20 to 120 days (including mobilisation, demobilisation and contingency), with a further 25 days for well testing, at each well location, depending on operational requirements. Only one well will be drilled at time, therefore, a MODU may be present within the PAA for up to two and a half years (potentially spread out over the five year approval period of the EP).

Support vessels will support the MODU. One vessel will be present within the vicinity of the MODU on standby at all times and the other/s will transit in and out of the Operational Area to port for emergency and routine operations. The support vessels will make approximately two to four trips per week.

An ISV may be used to install the Conductor Anchor Node (CAN), should it be used as an alternative method of conductor installation. The CAN unit is pre-installed prior to the MODU arriving on location, and takes approximately two days to install. During that time the installation vessel remains under DP control, without anchoring. The CAN will be recovered with an ISV within ±6 months of the well finishing. The CAN is pumped out using an ROV. In the unlikely event that the CAN does not come out, it will be left on the bottom with the wellhead in situ. The removal of the CAN can take approximately three days.

In total, each well could take approximately 147 days including planned activities, contingency activities, well testing and CAN removal.

The presence of the MODU, ISV and associated support vessel movements could present a navigational hazard to shipping and commercial fishing activities in the PAA.

On completion of a well, the wellhead assembly may be left in-situ, if routine removal techniques are unsuccessful. The wellhead left in-situ could potentially interfere with third party activities (in particular, fishing activities).

Impact Assessment

Displacement to Commercial Fishing Activities

A number of Commonwealth and State managed fisheries occur in the PAA. The PAA overlaps two Commonwealth and nine State managed fisheries. However, only two fisheries, the Pilbara Demersal

Scalefish Managed Fisheries (Pilbara Trawl, Trap and Line) and the Onlsow Prawn Managed Fishery, are considered to be active in the vicinity of the PAA. The PAA is located in water depths ranging from approximately 100–129 m, which is within the depth range where typical fishing effort occurs for the Pilbara Demersal Scalefish Managed Fisheries (Pilbara Trawl, Trap and Line), and therefore there is a potential for interactions with participants in the commercial fishery. Given the current level of effort within the Onlsow Prawn Managed Fishery and the large area where they can operate outside the PAA, interactions with participants in this fishery during the Petroleum Activities Program are unlikely (only one vessel operating). There was no direct response from licence holders during the consultation period with participants in this fishery.

The presence of commercial fishing vessels in the PAA would likely be short term, potentially resulting in a minor interference (navigational hazard) and localised displacement/avoidance by commercial fishing vessels within the immediate vicinity of the MODU or ISV during CAN installation and removal (if required). However, there was no direct response from commercial fisheries during the stakeholder consultation period, and as such the potential impact is considered to be minor and temporary.

Potential impacts to commercial fishing in the event the wellhead remains in-situ are snag hazards of fishing equipment such as trawl nets that operate along the seabed. Area 1 of the Pilbara Trawl Fishery overlaps with the PAA and may be operating at these water depths. No direct responses from commercial fisheries regarding snagging risks were received during the stakeholder consultation period.

Displacement of Recreational Fishing

Stakeholder consultation did not identify any key recreational fishing activity within the PAA. Recreational fishing in the region is concentrated around the coastal waters and islands of the NWMR such as the Montebello Islands (approximately 85 km from the PAA). Due to the distance offshore and water depths, recreational fishing is unlikely to occur in the PAA. In the event that recreational fishing effort occurred within the Operational Areas while drilling is being undertaken, displacement as a result of the Petroleum Activities Program would be minimal and relate only to the 500 m petroleum safety zone, around the MODU and the ISV during the CAN installation. Additionally, fishing activity may be excluded from the immediate area around the ISV during CAN installation (if required). Therefore, the potential impact is considered to be slight and would be isolated to only short term impacts to reputation and brand.

Given the distance of the PAA offshore, snagging hazards to recreational fishing equipment as a result of the wellhead remaining in-situ are highly unlikely.

Displacement to Commercial Shipping

The presence of the MODU, ISV and support vessels could potentially cause temporary disruption to commercial shipping. The PAA does not overlap with designated shipping fairways in the region although commercial vessel traffic is relatively high. Shipping in the area is mainly related to the resources industry, and particularly associated with the Woodside operated North Rankin Complex. During stakeholder consultation, AMSA noted that the MODU, ISV and support vessels are likely to encounter commercial shipping, based on historic vessel activity from March to May 2017. The potential impacts associated with this Petroleum Activities Program include displacement of vessels as they make slight course alteration to avoid the MODU or ISV. Therefore, the potential impact is considered to be isolated and temporary.

Given the water depth of the proposed wells (100 m minimum), impacts to commercial shipping as a result of the wellhead remaining in-situ are not considered credible.

Cumulative Impacts

There are no cumulative impacts from drilling activities, as no wells will be drilled concurrently. However, there may be cumulative impacts to commercial fisheries if multiple wellheads are left in situ although no direct responses from commercial fisheries regarding snagging risks were received during the stakeholder consultation period.

Summary of Potential Impacts to Environmental Value(s)
Given the adopted controls, it is considered that physical presence of the MODU, ISV, support vessels and the potential presence of wellheads left in-situ will not result in a potential impact greater than slight, short term impact to shipping and commercial/recreational fishing interests (i.e. Reputation and Brand Impacts - E).

Summary Control Measures
• Marine Orders 30 (Prevention of Collision) 2016.

- Marine Order 21 (Safety of navigation and emergency procedures) 2016.
- Establishment of a 500 m petroleum safety zone around MODU, and ISV during CAN installation and communicated to marine users.
- A support vessel is on standby, as required, during drilling activities to communicate with third-party vessels and assist in maintaining the petroleum safety zone.
- The support vessel will undertake surveillance/watch actions to prevent unplanned interactions when designated as being on standby.
- Notify Australian Hydrographic Service (AHS) of activities and movements prior to the MODU being on location.
- Notify AMSA Joint Rescue Coordination Centre (JRCC) of activities and movements.
- Undertake consultation with relevant stakeholders on activities which extends beyond the scope of the Petroleum Activity Program consultation.
- No concurrent drilling permitted during the Petroleum Activity Program.
- Attempt routine removal of wellheads/CAN.

Physical Presence: Disturbance to Benthic Habitat from MODU Anchoring, Drilling Operations and ROV Operation

Impacts and Risks Evaluation Summary														
Source of Impact	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Disturbance to seabed from drilling operations.					X			A	F	-	-	GP PJ	Broadly acceptable	EPO 5
Disturbance to seabed from installation of conductor with CAN (alternate method).					X			A	F	-	-			
Disturbance to seabed from ROV operation (including localised sediment relocation from jetting activities).					X			A	F	-	-			
Disturbance to seabed from MODU station holding (MODU mooring, including anchor holding testing).					X			A	E	-	-			
Disturbance to seabed from wellhead remaining in-situ (if required).					X			A	F	-	-			

Description of Source of Impact

Drilling

Drilling activities will result in direct seabed disturbance of up to 100 m radius around the well location due to the installation of the BOP and conductor. The generation and discharge of cuttings and drilling fluids are not considered in this section.

Conductor installation with CAN

If a CAN unit is used to install the offline conductor, the placement of the CAN on the seabed could result in localised disturbance to the seabed and relocation of sediments surrounding the location of the well. However, observations during the CAN installation during drilling of the Ferrand exploration well did not detect any distinct seabed disturbance.

The CAN unit is approximately 6 m diameter and 12–18 m in length and, if used, will discharge sediment to the seabed for only a short period while the top hole section of the well is installed and while the CAN is removed, both take approximately two days.

MODU Anchoring and Anchor Holding Testing

Seabed disturbance will result from the anchor holding testing and MODU anchor mooring system, including placement of anchors and chain/wire on the seabed, potential dragging during tensioning and recovery of anchors. Overall, the mooring of the MODU and anchor holding testing activities will result in localised, small scale seabed disturbance in relation to the spatial extent of the benthic habitats. Mooring may require a 12 point pre-laid mooring system at each well location depending on the time of year. Since the drilling of the Achernar exploration well is intended to occur outside the cyclone season, a standard 8 point system is more likely. There are six well locations for the Petroleum Activities Program, comprising three exploration and three appraisal wells, equating to the need for up to 72 anchor installations, assuming all implement the 12 point mooring system.

The planned anchoring activities fall within the scope of the *Anchoring of Vessels and Floating Facilities*

Environment Plan Reference Case (Department of Industry, Innovation and Science, undated):

- all anchoring activities undertaken by vessels and floating facilities (excluding FPSOs and FLNGs) while undertaking petroleum activities
- locations of water depth greater than 70 m. This boundary is set to exclude areas of sensitive primary producer habitats (e.g. corals, seagrass) that occur in shallower waters
- installation of moorings, buoys, equipment or other infrastructure for a period of up to 2 years
- wet storage on seabed of anchor chains, etc. during activities up to 2 years
- activities with total areas of seabed disturbance less than 13,000 m^2.

ROV

The use of the ROV during Petroleum Program Activities may result in temporary seabed disturbance and suspension of sediment causing increased turbidity as a result of working close to, or occasionally on, the seabed. ROV used close to or on the seabed is limited to that required for effective and safe subsea activities. The footprint of a typical ROV is approximately 2.5 m x 1.7 m. Additionally, the ROV may be used to relocate sediment material around the well location (known as jetting) to help manage cement or cuttings flow. This will cause localised and temporary impacts to water quality from increased turbidity and may cause localised and temporary impacts to benthic habitats.

Wellhead Remains In-Situ

Once drilling is complete, well infrastructure will be removed (except in the event that the routine wellhead removal techniques are unsuccessful). If the wellhead remains in situ there would be localised seabed disturbance around the wellhead location.

Impact Assessment

Deepwater Benthic Habitats

Drilling operations, MODU mooring (including anchor hold testing), CAN conductor installation and ROV operations are likely to result in localised physical modification to a small area of the seabed and disturbance to soft sediment. Bathymetry surveys indicate the seabed within the PAA is relatively flat and featureless, including the northern portion of the PAA which overlap the Ancient Coastline at the 125 m Depth Contour ('Ancient Coastline') KEF.

For the seabed disturbance impacts of anchoring, we refer to *Anchoring of Vessels and Floating Facilities Environment Plan Reference Case* (Department of Industry, Innovation and Science, undated).

The ancient coastline overlaps the PAA. The Ancient Coastline is not continuous throughout the Northwest Shelf, and coincides with a well-documented eustatic still stand at approximately 130 m worldwide (Falkner *et al*., 2009). Where the Ancient Coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (DSEWPaC, 2012a). Parts of the Ancient Coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment. The escarpment type features may also potentially facilitate mixing within the water column due to upwelling, providing a nutrient rich environment. Although the ancient coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner *et al*., 2009). Seabed disturbance is unlikely to influence upwelling and therefore not expected to impact on the ecological value of the Ancient Coastline at 125 m Depth Contour KEF.

The PAA, including the Ancient Coastline at 125 m Depth Contour KEF, is expected to consist primarily of soft, fine unconsolidated sediments, which are typical of the broader NWMR.

A number of targeted surveys to investigate epibenthos and infauna of offshore NWS shelf and slope environments have been carried out by Woodside. These surveys have included grab samples of seabed sediments from around North Rankin Complex (NRC), Goodwyn A and Angel platforms and the export pipeline route (Sinclair Knight Merz, 2006) and the surrounding area, which are considered to be representative of the PAA. The seabed surveys conducted along the export pipeline route revealed infauna dominated by polychaetes and crustaceans which were associated with the soft, unconsolidated sediment in this area of the NWS (Bowman Bishaw Gorham, 2000; Sinclair Knight Merz, 2006). These results supported the findings of other NWS sampling programs which indicated a widespread and well represented infauna assemblage along the continental shelf and upper slopes (Rainer, 1991; LeProvost, Dames and Moore, 2000; Woodside, 2004; Brewer *et al*., 2007; RPS, 2011).

Impacts from drilling activities, including CAN installation, are expected to be confined to sediment burrowing infauna and surface epifauna invertebrates, particularly filter feeders, inhabiting the seabed directly around the well location, typically within 100 m of the well (Gates and Jones, 2012; Hughes *et al*., 2010). Impacts to these broadly represented communities are expected to be highly localised with no significant impact to environment receptors.

ROV activities near the seafloor and small amounts of sediment relocation may result in slight and short-term impacts to deepwater biota, detailed above, as a result of elevated turbidity and the clogging of respiratory and feeding parts (turbidity) of filter feeding organisms. However, elevated turbidity would only be expected to be very short-term and temporary, and is therefore, not expected to have any significant impact to environment receptors, particularly given the low densities of benthic organisms at the water depths of the PAA. The suction process used during CAN installation ceases should sediment be pumped in. ROV footage during CAN installation in previous activities (Ferrand exploration well) did not detect any sedimentation or distinct seabed disturbance in the proximity of the well.

In the unlikely event the wellhead cannot be removed, over time, the cement surrounding the wellhead will likely become buried in sediment as a result of prevailing ocean currents. Over time, the steel wellhead structure will corrode and marine fouling is expected to accumulate, whereby a marine life structure may remain above the seafloor. The wellhead remaining in-situ is expected to have a localised impact not significant to environment receptors. No further impacts to benthic habitats are likely.

Cumulative Impacts

Given the number of wells planned to be drilled during the Petroleum Activities Program, and the historically drilled Eaglehawk-1 well, there is the potential for cumulative disturbance to the seabed and benthic communities. Cumulative seabed disturbance associated with the Petroleum Activities Program is expected to be restricted to an accumulation of disturbance areas from overlapping well footprints (in the event well locations are within hundreds of meters of each other).

Furthermore, as the nature of the activity (appraisal and exploration well drilling) is to characterise hydrocarbons within an area, the likelihood of wells being drilled in close proximity is low. Furthermore, given the fact that benthic habitats within the PAA are well represented throughout the NWS and wider NWMR, cumulative impacts associated with seabed disturbance from overlapping well footprints are not expected to significantly increase the risk to benthic habitats present within the PAA.

Summary of Potential Impacts to Environmental Value(s)

Given the adopted controls, seabed disturbance from the petroleum activity program will result in localised, slight and short-term impacts to benthic habitat and communities (i.e. Environment Impact - E).

Summary of Control Measures

- Woodside Basis of Well Design includes environmental sensitivity and seabed topography to inform the selection of the MODU well site locations.
- Anchors installed as per mooring design analysis to ensure adequate MODU station holding capacity.
- Only use DP ISV (no routine anchoring required).

Routine Acoustic Emissions: Generation of Noise from VSP

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Generation of acoustic signals from VSP.					X	X		A	F	-	-	LCS GP PJ	Broadly acceptable	EPO 6 & 7

Description of Source of Impact

Vertical Seismic Profiling (VSP) operations can generate noise that could exceed ambient noise levels generated by wind and wave action and biological noise (ambient noise levels range from around 90 dB re 1 µPa under very calm, low wind conditions, to 120 dB re 1µPa under windy conditions) (McCauley, 2005).

VSP is a standard method used during well logging. The duration of VSP is short, up to 24 hours for each of the wells (six lots of 24 hours during the Petroleum Activities Program) and utilises relatively small airguns that generate impulsive low frequency noise.

The VSP source (typically 750 cui and comprising of three 250 cui airguns) is expected to generate a peak pressure around 239 dB re 1 µPa @ 1 m, a sound pressure level (SPL) of 224 dB re 1 µPa^2 and sound exposure level (SEL) of 225 dB re 1 µPa^2.s @ 1 m with the majority of the noise concentrated at low (<100 Hz) frequencies (Jimenez-Arranz *et al*., 2017).

Impact Assessment

To determine impacts to EPBC listed species, an assessment was undertaken of the expected ranges of noise levels that could result in impacts. When acoustic waves propagate through water, there is a significant loss of intensity due to geometric spreading, reflection, absorption and scattering (International Association of Oil and Gas Producers, 2008). The sum of these losses is referred to as transmission loss. The short range spherical spreading loss component of this can be estimated to determine expected noise levels at short range using the spherical spreading loss calculation below:

$$\text{Transmission Loss (TL)} = 20 \log_{10}(r) + \alpha r$$

Where:

- *r* is the slant range between the source and the receiver
- α is the frequency dependent absorption coefficient for seawater (dependent on temperature, pH and salinity) calculated using the equation of Fisher and Simmons (1977); estimated to be 0.001 for typical seawater in the PAA. Note that for low frequency sound, such as VSP, the contribution of α to transmission loss is small compared to the geometric spreading term.

Based on this equation the expected range where noise levels will be equal to or greater than the relevant thresholds detailed in **Table 12-1**.

Table 12-1: Noise level thresholds for cetaceans, marine turtles and whale sharks, and expected distance from the source where noise levels will dissipate to below the relevant thresholds

Species Group	Threshold		Expected range of noise levels ≥ thresholds
Cetaceans	Permanent threshold shift	230 dB re 1 µPa OR 198 dB re 1 µPa^{2}s	~3 m ~23 m

	Behavioural Response	160 dB re 1 µPa^2	~1600 m
Marine Turtles	Permanent threshold shift	No data available	NA
	Behavioural Response	166 dB re 1 µPa^2	~800 m
Whale Sharks	Permanent threshold shift	>213 dB re 1 µPa OR >216 dB re 1 µPa^{2}s	~20 m OR ~3 m
	Behavioural Response	No data available	NA

<u>*Marine Fauna (Cetaceans)*</u>

Elevated underwater noise can affect marine fauna, such as whales, in three main ways (*Oceans of noise*, 2004; Richardson *et al*., 1995; Southall *et al*., 2007):

- by causing direct physical effects on hearing or other organs (injury)
- by masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)
- through disturbance leading to behavioural changes or displacement from important areas.

Available data on marine mammal behavioural responses to pulsed sounds are highly variable and context-specific. Recent studies on the behavioural response to humpback whales to seismic airguns has demonstrated behavioural response to seismic airguns above received sound exposure levels of 140 dB re 1 µPa^2.s (SEL) (Dunlop *et al.,* 2017). This study used the behavioural response of humpback whales to noise from two different moving air gun arrays (20 and 140 cubic inch air gun array) to determine whether a dose–response relationship existed. To do this, a measure of avoidance of the source was developed, and the magnitude (rather than probability) of this response was tested against dose. The proximity to the source, and the vessel itself, was included within the one-analysis model. Humpback whales were more likely to avoid the air gun arrays (but not the controls) within 3 km of the source at sound exposure levels over 140 dB re. 1 µPa^2.s, meaning that both the proximity and the received level were important factors and the relationship between dose (received level) and therefore the 140 dB re. 1 µPa^2.s cannot be adopted as a standalone threshold if the source proximity is greater than 3 km. This study tested towing an airgun source directly into the incoming path of a southern humpback migration which included mother and calf humpback whales; therefore, the context and applicability of these results may not be directly applicable to the behavioural response to all cetaceans in every context and has not been adopted for the assessment of potential behavioural impacts from VSP due to that fact that the source is stationary. It should be noted that Dunlop *et al*. (2017) makes reference that their results are surprisingly consistent with previous studies with humpback whales in different behavioural contexts. For example, feeding humpback whales, responded at ranges up to 3 km from the source, at levels of 150–169 dB re. 1 µPa (Malme *et al*., 1985) and resting female humpback whales with calves displayed avoidance reactions at 140 dB re. 1 µPa, though other cohorts reacted at higher levels (157–164 dB re. 1 µPa; McCauley *et al*., 2003)."

The United States (US) National Marine Fisheries Service guidance (NMFS, 2005) sets the Level B harassment threshold for marine mammals at 160 dB re 1 µPa (RMS) for impulsive noise. The value for impulsive sound sits in the upper-mid range for disturbance impacts identified in Southall et al. (2007) and in alignment with other studies referred above (McCauley *et al*., 2003; Mamle *et al*., 1985); consequently, this criterion has been used (in lieu of more suitable up to date criteria) for assessing onset of potentially strong behavioural reaction in this assessment.

The relevant criteria proposed by Southall *et al.* (2007) for assessing the potential for permanent threshold shift due to multiple and single pulse sounds are considered to be an un-weighted peak pressure level of 230 dB re 1 µPa and an M-weighted SEL of 198 dB re 1 µPa^2.s for all cetaceans. These injury criteria values are derived from values for onset of TTS with an additional allowance of +6 dB for peak sound and +15 dB for SEL to estimate the potential onset of PTS (Southall *et al.,* 2007).

<u>*Marine Fauna (Fish and Marine Turtles)*</u>

There is a paucity of data regarding responses of marine turtles, whale sharks and rays to underwater noise. Popper *et al*. (2014) investigated, through a literature review, mortality, impairment and behaviour thresholds for fishes and found greater than 186 dB re 1 μPa².s was required to elicit even a temporary threshold shift (TTS) for fish (**Table 12-2**). Fishes have been shown to suffer auditory cell damage following exposure to high intensity noise (McCauley *et al*., 2003); the noise level that induced damage in this experiment exceeded that of the VSP source to be used during the Petroleum Activities Program.

The Popper *et al*. (2014) review also assessed thresholds for marine turtles and found qualitative results that TTS was only high for near field exposure, while TTS was low for both intermediate and far field exposure (Popper *et al*. 2014). McCauley *et al*. (2000) noted that sea turtles exhibit increased swimming activity at 166 dB re 1 uPa².

Table 12-2: Threshold for seismic airguns (impulsive) exposure to fish and sea turtles (adopted from Popper *et al*. 2014)

Type of Animal	Impairment			Behaviour
	Recoverable Injury (PTS)	**Temporary Threshold Shift (TTS)**	**Masking**	
Fish 1 – no swim bladder (particle motion detector)	>216 dB re 1 μPa² s (cSEL) Or >213 dB re 1μPa (SPL peak)	>186 dB re 1 μPa² s (cSEL)	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish 2 – Swim bladder is not involved in hearing (particle motion detector)	203 dB re 1 μPa² s (cSEL) Or >207 dB re 1μPa (SPL peak)	>186 dB re 1 μPa² s (cSEL)	(N) Low (I) Low (F) Moderate	(N) High (I) Moderate (F) Low
Fish 3 – Swim bladder involved in hearing (primary pressure detection)	203 dB re 1 μPa² s (cSEL) Or >207 dB re 1μPa (SPL peak)	186 dB re 1 μPa² s (cSEL)	(N) Low (I) Low (F) Low	(N) High (I) High (F) Moderate
Sea turtles	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low

* *Relative risk: near (N), intermediate (I) and far (F)*

Impact to EPBC Listed Species

Controls including marine fauna observers will reduce potential impacts by allowing animals to move from the source of the sound to beyond the 1600 m threshold zone (behavioural response for cetaceans). Any impacts to whale sharks, cetaceans and marine turtles is expected to be limited to short-term avoidance of a localised area with no long-terms impacts.

Seasonal Sensitivities of Marine Fauna

The use of VSP has the potential to cause temporary (up to approximately 24 hours for each well) and localised disturbance to marine fauna in response to received noise levels of 160 dB re 1 μPa (RMS). As the Petroleum Activities Program may take place at any time, VSP may overlap with the migration seasons for humpback whales, blue whales, pygmy blue whales, sei whales, fin whales and whale sharks. Although, the PAA does not overlap with the migration BIA for pygmy blue whales or humpback whales, the overlap with the distribution BIA for pygmy blue whales, and the close proximity of the PAA to the humpback whale migration BIA, it is possible that these species will occur in the vicinity of the PAA at various times during the year, with increased numbers during peak periods. Given that the PAA overlaps with the whale shark foraging BIA, presence of this species during peak periods (May to July) is expected. However, even with an increased likelihood of interaction the potential impacts are considered to be localised and not significant to environmental receptors (as described above).

It is reasonable to expect that cetaceans, whale sharks, rays and marine turtles may demonstrate avoidance or attraction behaviour in the vicinity of the VSP activity. However, any avoidance or attraction behaviours displayed by these transient animals resulting from the VSP activities are expected to be localised and temporary, based on the short duration of the VSP activities. Furthermore, VSP activities will be spread out sporadically for the six wells. The intensity of noise dissipates with distance from its source. Based on the likely low abundance of MNES species in close proximity to the PAA and the properties of the noise emissions, it is considered not likely that there will be any significant impacts.

Other Communities (zooplankton)

Zooplankton in the PAA is expected to be similar to offshore waters and include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs. Experiments by McCauley *et al.* (2017) indicated that seismic activity, based on the use of a 150 cui airgun, may significantly decrease abundance of some zooplankton (copepods, cladocerans and euphausiids larvae) and increase the mortality rate. However, zooplankton populations are expected to recover quickly due to their fast growth rates and the dispersal and mixing of zooplankton from outside the impacted area (Richardson *et al*., 2017). Therefore, due to the short duration of the use of the VSP (up to approximately 24 hours for each well) and the expected recovery impacts are expected to be localised with no lasting effect.

Cumulative Impacts

There are no cumulative impacts, as no wells will be drilled concurrently.

Summary of Potential Impacts to Environmental Value(s)

VSP may be conducted for up to 24 hours during the Petroleum Activities Program (so potentially 6 x 24 hour periods spread out over the duration of the EP). Given the adopted controls, it is considered that VSP operations will not result in a potential impact greater than localised disruption with no lasting effect. (i.e. Environment Impact - F).

Summary of Control Measures

- VSP Operations in accordance with Vertical Seismic Profiling Procedure for Woodside Contracted Rigs.
- VSP pre-start visual observations and operating procedures for cetaceans, whale sharks and turtles.
- No concurrent drilling permitted during the Petroleum Activity Program.

Routine Acoustic Emissions: Generation of Noise from Activity Vessels, MODU, Positioning Equipment and Helicopter Transfers

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Generation of acoustic signals from drilling, support vessels and ISV during normal operations.						X		A	F	-	-	GP PJ	Broadly acceptable	N/A
Generation of acoustic signals from dynamic positioning systems on DP ISV.						X		A	F	-	-	GP PJ	Broadly acceptable	N/A
Generation of atmospheric noise from helicopter transfers.						X		A	F	-	-	GP PJ	Broadly acceptable	N/A

Description of Source of Impact

The MODU, ISV, support vessels and helicopters will generate noise both in the air and underwater, due to the operation of thrusters engines, propeller movement, drilling operations, etc. These noises will contribute to and can exceed ambient noise levels which range from around 90 dB re 1 µPa (root square mean sound pressure level (RMS SPL)) under very calm, low wind conditions, to 120 dB re 1µPa (RMS SPL) under windy conditions (McCauley, 2005).

MODU Noise

Noise associated with a moored MODU will be restricted to drilling activities, such as drill pipe operations and on board machinery. A range of broadband values (59 to 185 dB re 1 µPa at 1 m (RMS SPL)) have been quoted for various MODUs (Simmonds et al., 2004), where noise is likely to be between 100 to 190 dB re 1 µPa at 1 m (RMS SPL) during drilling and between 85 to 135 dBre 1 µPa at 1 m (RMS SPL) when not actively drilling. McCauley (1998) recorded received noise levels approximately 117 dB re 1 µPa at 1 m (RMS SPL) at 125 m from a moored MODU while actively drilling (with support vessel on anchor).

The MODU is expected to be on location for up to 120 days for each exploration/appraisal well, over a five year period.

ISV and Support Vessel Noise

The main source of noise from a DP vessel (such as ISVs) relates to the use of DP thrusters. There is no applicable sound data available for a typical DP ISV; however, frequencies and sound levels are expected to be similar to those from a DP drill ships (e.g. MODU). DP MODU underwater noise measurements were taken for the Maersk Discoverer drill rig used on the North West Shelf (NWS) (Woodside, 2011) showed the system emitted tonal signals between 200 Hz and 1.2 kHz, which is within the auditory bandwidth of cetaceans. The measured source level was between 176 and 185 dB re 1µPa at 1 m. A noise assessment for the Deepwater Millennium (McPherson *et al*., 2013) estimated the broadband source level for drilling operations at 196 dB re 1µPa at 1 m, with all six thrusters working at 100%. The 196 dB re 1µPa at 1 m, estimated above is expected to be worst case as the ISV is not expected to operate on 100% DP capacity on a continual basis.

Support vessels and ISV will use DP while the vessel is maintaining position. McCauley (1998) measured underwater broadband noise equivalent to approximately 182 dB re 1 μPa at 1 m (RMS SPL) from a support vessel holding station in the Timor Sea; it is expected that similar noise levels will be generated by support vessels used for this Petroleum Activities Program.

Note that all support vessels, and the ISV, are required to comply with EPBC Regulation 2000 – Part 8 Interacting with Cetaceans to reduce the likelihood of collisions with cetaceans. Implementing this control may incidentally reduce the noise generated by vessels in proximity to cetaceans as vessels will be travelling slower; slower vessel speeds may reduce underwater noise from machinery noise (main engines) and propeller cavitation.

Generation of Noise From Helicopter Transfers

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Activities relevant to the PAA will relate to the landing and take-off of helicopters on the MODU or vessel helidecks. Helicopter flights are at their lowest (i.e. closest point to the sea surface) during these periods of take-off and landing from helidecks, which constitutes a relatively short phase of routine flight operations. During these critical stages of helicopter operations, safety takes precedence.

Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance have been measured at up to a maximum of 90.6 dB (BMT Asia Pacific, 2005). Unconstrained point source noise in the atmosphere (such as helicopter noise) spreads spherically (Truax, 1978), with noise received at the sea surface decreasing with increasing distance from the aircraft (Nowacek *et al*., 2007). Based on spherical geometric spreading (and not considering transmission loss from atmospheric absorption), the sound level is expected to decrease by 6 dB for every doubling of the distance from the source (Truax, 1978). Using this model, a maximum sound level of approximately 90 dB at 150 m would be reduced to approximate 76 dB directly below a helicopter travelling at an altitude of 500 m.

Impact Assessment

The PAA is located in waters approximately 100–129 m deep. The fauna associated with this area will be predominantly pelagic species of fish, with migratory species such as turtles, whale sharks and cetaceans present in the area seasonally.

Elevated underwater noise can affect marine fauna, including cetaceans, fish, turtles, sharks and rays in three main ways (Richardson et al., 1995; Simmonds *et al*., 2004):

(1) by causing direct physical effects on hearing or other organs (injury)

(2) by masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey)

(3) through disturbance leading to behavioural changes or displacement from important areas.

The thresholds that could result in behavioural response for cetaceans is expected to be 120 dB re 1 μPa^2 for continuous noise sources, and 160 dB re 1 μPa (RMS) for impulsive noise sources. These thresholds are adopted by the United States National Oceanic and Atmospheric Administration (NOAA) and are consistent with the levels presented by Southall *et al.* (2007). More permanent injury would be expected to occur at 230 dB re 1 μPa (peak) (Southall *et al*., 2007). Noise generated by a DP ISV or support vessels to be used for this Petroleum Activities Program does not exceed that level so permanent injury to protected species is not anticipated.

Listed threatened and listed migratory species that could be potentially impacted by noise and vibration may be present within the PAAs and primarily include cetaceans as well as whale sharks, rays and turtles. The PAA overlaps the distribution BIA for pygmy blue whales, but not with known migration pathways. Therefore, pygmy blue whale individuals may be encountered, but not in large numbers. While not overlapping any BIA, the PMST results identified that humpback whales have the potential to occur in proximity of the PAA, in particular during the migration period (July (northbound) and late August/September (southbound)). Additional cetaceans likely to occur include the sei whale and fin whale. The PAA also overlaps with the whale shark foraging BIA, with peak numbers expected March to July.

MODU, ISV and Support Vessels

It is likely that there may be increased numbers of individuals of pygmy blue whales and humpback whales within the PAA during the seasonal periods described above. However, given that the PAA does not overlap with migration BIAs for these species, the potential impacts are considered to be not significant given the relatively low importance of the area to migration behaviour and that noise levels associated with routine operations of vessels and the MODU. It is reasonable to expect that fauna may demonstrate avoidance or attraction behaviour to the noise generated by the Petroleum Activities Program. Note that the PAA is surrounded by open water, with no restrictions (e.g. shallow waters, embayments) to an animal's ability to avoid the activities. Additionally, only one well will be drilled at a time, therefore, multiple petroleum activities which may impede migration routes further, will not occur. Predicted noise levels from the MODU, ISV and support vessels are not considered to be ecologically significant at a population level.

Other fauna associated with the PAA will be predominantly pelagic species of fish with migratory species such as whale sharks, rays, marine turtles and other cetacean species transiting through the PAA. Therefore, potential impacts from vessel noise are likely to be restricted to temporary avoidance behaviour to individuals transiting through the PAA, and are therefore, considered localised with no lasting effect. As the wells will not be drilled concurrently there is no potential for cumulative impacts from drilling concurrent wells.

Helicopter Noise

Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface (and vice versa) – the majority of the noise energy is reflected). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface; angles ±>13° from vertical being almost entirely reflected (Richardson *et al*., 1995). Given this, and the typical characteristics of helicopter flights within the PAA (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance are not considered to be credible. Note that helicopter noise during approach, landing and take-off is more likely to propagate through the sea surface due to the reduced air speed and lower altitude. However, helicopter noise during approach, landing and take-off will be mingled with underwater noise generated by the facility hosting the helipad (e.g. thruster noise from vessels, machinery noise from MODU, etc.). Additionally, approach, landing and take-off are relatively short phases of the flight, resulting in little opportunity for underwater noise to be generated.

Given the standard flight profile of a helicopter transfer, maintenance of a >500 m horizontal separation from cetaceans (as per the EPBC Regulations), and the predominantly seasonal presence of whales within the PAA, interactions between helicopters and cetaceans resulting in behavioural impacts are considered to be highly unlikely. In the highly unlikely event that cetaceans are disturbed by helicopters, responses are expected to consist of short-term behavioural responses, such as increased swimming speed; the consequence of such disturbance is considered to have no lasting effect and of no significance.

Turtles may be present in low numbers within the PAA, and may be exposed to helicopter noise when on the sea surface (e.g. when basking or breathing). Typical startle responses occur at relatively short ranges (tens of metres) (Hazel *et al*., 2007) and as such, startle responses during typical helicopter flight profiles are considered to be remote. In the event of a behavioural response to the presence of a helicopter, turtles are expected to exhibit diving behaviour, which is of no lasting effect.

The PAA overlaps the wedge-tailed shearwater breeding (August–April) and foraging BIAs. However, there are no nesting sites such as islands within the PAA. Seabirds with the PAA may avoid helicopter flights. Given the expected low density of seabirds within the PAA, the relative infrequency of helicopter flights and lack of lasting effect of potential behavioural responses to helicopter noise, the likelihood and consequence of subsequent impacts are considered to be highly unlikely and result in no lasting effect, respectively.

Positioning Equipment Noise

Due to the short duration of use and higher frequencies used by positioning equipment, the acoustic noise from the transponders is unlikely to have an effect on the behavioural patterns of marine fauna. Therefore, no impacts are anticipated from positioning transponders.

Summary of Potential Impacts to Environmental Value(s)
It is considered that noise generated by ISV, support vessels, MODU drilling activities, helicopters and positioning transponders will not result in a potential impact greater than localised impacts with no lasting effect, not significant to marine fauna. (i.e. Environment Impact - F).

Summary of Control Measures

- The potential impacts and risks from routine noise emissions (excluding VSP) are deemed to be ALARP in its current impact state. No reasonable additional/alternative controls were identified

that would further reduce the impacts and risks without grossly disproportionate sacrifice.

Routine and Non-routine Discharges to the Marine Environment: MODU and Project Vessels

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Routine discharge of sewage, grey water and putrescible wastes to marine environment from MODU, ISV and support vessels.			X					A	F	-	-	LCS GP PJ	Broadly Acceptable	EPO 7
Routine discharge of deck and bilge water to marine environment from MODU, ISV and support vessels.			X					A	F	-	-	LCS GP PJ	Broadly Acceptable	
Routine discharge of cooling water or brine to the marine environment from MODU, ISV and support vessels.			X					A	F	-	-	LCS GP PJ	Broadly Acceptable	

Description of Source of Impact

The MODU, ISV and support vessels routinely generate/discharge:

- small volumes (impact assessment based on approximate discharge of 250 m^3 per vessel/MODU per day) of treated sewage, putrescible wastes and grey water to the marine environment
- routine/periodic discharge of relatively small volumes of bilge water. Bilge tanks receive fluids from many parts of the support vessel, ISV or MODU. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals
- variable water discharge from MODU/vessel decks directly overboard or via deck drainage systems; sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks
- cooling water from machinery engines or mud cooling units and brine water produced during the desalination process of reverse osmosis to produce potable water on board the support vessels, ISV and MODU.

Environmental risk relating to the disposal/discharges above regulated levels or incorrect disposal/discharge of waste would be unplanned (non-routine/accidental).

Impact Assessment

The environmental impact associated with ocean disposal of sewage and other organic wastes (i.e. putrescible waste) is eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as oxygen depletion and phytoplankton blooms. Other contaminants of concern occurring in these discharges may include ammonia, E. coli, faecal coliform, volatile and semi-volatile organic compounds, phenol, hydrogen sulphide, metals, surfactants, and phthalates.

Woodside conducted monitoring of sewage discharges at their Torosa-4 Appraisal Drilling campaign which demonstrated that a 10 m^3 sewage discharge reduced to approximately 1% of its original concentration within 50 m of the discharge location. In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted and no elevations in water quality monitoring parameters (e.g. TN, total phosphorous and selected metals) were recorded above background levels at any station (Woodside Energy Limited, 2011). Mixing and dispersion would be further facilitated in deep offshore waters, consistent with the location of the PAA, through regional wind and large scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage discharges may occur. Studies investigating the effects of nutrient enrichment from offshore sewage discharges indicate that the influence of nutrients in open marine areas is much less significant than that experienced in enclosed areas (McIntyre and Johnston, 1975).

Furthermore, open marine waters do not typically support areas of increased ecological sensitivity, due to the lack of nutrients in the upper water column and lack of light penetration at depth. Therefore presence of other receptors such as fish, reptiles, birds and cetaceans in significant numbers, and in close proximity to the PAA, is unlikely. Research also suggests that zooplankton composition and distribution are not affected in areas associated with sewage dumping grounds (McIntyre and Johnston, 1975). Plankton communities are expected to rapidly recover from any such short-term, localised impact, as they are known to have naturally high levels of natural mortality and a rapid replacement rate.

Additional discharges outlined which may include other non-organic contaminants (e.g. bilge water, deck drainage and cooling water), will be rapidly diluted through the same mechanisms as above and are expected to be in very small quantities and concentrations as to not pose any significant risk to any relevant receptors. As such, no significant impacts from the planned (routine and non-routine) discharges that are listed above are anticipated because of the minor quantities involved, the expected localised mixing zone and high level of dilution into the open water marine environment of the PAA. The PAA is located more than 12 nm from land, which exceeds the exclusion zones required by Marine Order 96 (Marine pollution prevention – sewage) 2018 and Marine Order 95 (Marine pollution prevention – garbage) 2013.

Cumulative Impacts

While the Petroleum Activities Program may extend for several years, vessels will not be continuously in the PAA during this time, vessels will also be moving (i.e. not in a in a single location for an extended period of time (i.e. max time of MODU at any one drilling locations is ~120 days). Rather, these routine and non-routine discharges are expected to be intermittent in nature for the duration of the Petroleum Activities Program. Therefore, cumulative impacts to water quality within the PAA are expected to be localised and short-term with no lasting effect.

It is possible that marine fauna transiting the localised area may come into contact with these discharges (e.g. marine turtles, humpback whales, pygmy blue whales, fin whales, sei whales, whale sharks as they traverse the PAA), however, given the localised extent of cumulative impacts from multiple vessel discharges within the PAA, significant impacts to marine fauna are not expected.

Summary of Potential Impacts to environmental values(s)

Given the adopted controls, it is considered that routine or non-routine discharges described will not result in a potential impact greater than localised contamination not significant to environmental receptors, with no lasting effect. (i.e. Environment Impact - F).

Summary of Control Measures

- Marine Order 95 – pollution prevention – Garbage (as appropriate to vessel class).
- Marine Order 96 – pollution prevention – Sewage (as appropriate to vessel class).
- Engineering Standard – Rig Equipment which specifies requirements for deck drainage and management of oily water for MODU.
- Marine Order 91 – oil (as relevant to vessel class).

Routine and Non-routine Discharges to the Marine Environment: Drill Cuttings and Drilling Fluids (WBM and NWBM)

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Routine discharge of WBM drill cuttings to the seabed and the marine environment.		X	X		X			A	E	-	-	LCS GP PJ	Broadly Acceptable	EPO 8
Routine discharge of NWBM drill cuttings to the seabed and the marine environment.		X	X		X			A	E	-	-			
Routine discharge of drilling muds (WBM) to the seabed and the marine environment.		X	X		X			A	E	-	-			
Non-routine discharge of wash water from mud pits and vessel tank wash fluids.		X	X		X			A	E	-	-			
Routine discharge of well clean-up and DST fluids.		X	X					A	E	-	-			
Discharge of well annular fluids from temporarily abandoned well.		X	X		X			A	F	-	-			

Description of Source of Impact

Drilling Program

The proposed Petroleum Activities Program includes the drilling of up to six wells (three appraisal and three exploration) all at a seabed depth ranging from approximately 100 to 129 m.

The location of one of the wells - the Achernar exploration well has been confirmed. The Achernar exploration well has a TD of approximately 3500 m total vertical depth subsea (TVDSS). The other wells which may be drilled are not expected to have TVDSS greater than 3500 m; therefore, the volumes of drill cuttings and muds for the Achernar exploration well is considered worst case and will be used to represent volumes produce from each of the other five wells that may be drilled. Given the other wells are yet to be decided, estimates of drill cutting volumes are provided in **Table 12-3** for four drilling scenarios:

- Base case: e.g. typical drilling operations for the management of cuttings is to discharge into the marine environment along with WBM drilling muds which are used to transport the cuttings out of the well.
- CAN: use of a CAN as alternative to 36” conductor.
- Riserless Mud Recovery (RMR): may be implemented for technical reasons.
- NWBM: Use of NWBM should they be required. If used during this Petroleum Activities Program, NWBM will not be bulk discharged to the marine environment.

For the Achernar exploration well (the only confirmed well), the use of CAN or RMR is possible but not confirmed, it is not expected that NWBM will be required. The following describes the source of risk with respect to discharge of drill cuttings, mud and clean-up fluids only.

Wells will be drilled as a series of sections, as detailed in **Table 12-3**. The top hole sections of each well will be drilled without a riser in place (i.e. riserless drilling). Upon drilling of the top hole sections, casings will be cemented in place, a BOP installed and a riser put in place between the BOP and the MODU. The riser remains in place during drilling of the bottom hole sections and facilitates the circulation of drilling fluids and cuttings between the well bore and the MODU.

Table 12-3: Estimated discharges of cuttings and volumes of drilling fluids used for the Petroleum Activities Program[2]

Scenario	Well Section	Section width (inches)	Cuttings volume (m^3)	Hole section	Drilling Fluid Type	Drilling Fluid Discharge Volume (m3)	Discharge Point (Cuttings)
Base Case	36" Conductor	42	116	Top	Seawater/gel sweeps	331	Seabed
CAN	Alternative to 36" Conductor: CAN	6 m	0–10		No fluids pumped, Suction process utilised	-	
Base Case	13-3/8" Casing	17.5	446	Top	Seawater/gel sweeps	2458	Seabed
RMR					WBM	1843	Below Sea Surface
Base Case RMR	12-1/4" OH	12.25	144	Bottom	WBM	1619	Below Sea Surface
NWBM					NWBM	581 (not discharged)	
Total for Planned Activities (per well)			**705**				
Contingent Activities (Complete Well x1) + Respud/Sidetrack Allowance x1[3]	6 wells + contingent activities						
	Approximate Campaign Total Volume		**5000**				

Drill Cuttings

Indicative drill cuttings generated from drilling the Achernar exploration well have been estimated to comprise a total of approximately 705 m^3. Typically, drilling generates drill cuttings ranging in size from very fine (0.016 mm) to very coarse (<1 cm) particle/sediment sizes, determined by TD, lithology, drill bit employed and SCE specifications. Indicative volumes of drill cuttings for the well are outlined in **Table 12-3**.

Cuttings resulting from drilling the top hole section are drilled using a seawater, pre-hydrated bentonite sweeps drilling fluid (WBM) system, discharging the cuttings to the seabed at the well site where they will accumulate near the wellhead or if a Riserless Mud Recovery (RMR) system is installed, the cuttings are discharged at the sea surface (with mud recycled downhole). If a CAN is used in place of the 36" conductor, cuttings from this section will be negligible.

The bottom hole sections will be drilled with a marine riser that enables cuttings and drilling fluid to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the Solid Control Equipment (SCE). The SCE uses shale shakers to remove coarse cuttings from the drilling fluids. After processing by the shale shakers, the recovered fluids from the cuttings may be directed to centrifuges, which are used to remove fine solids (~4.5 to 6 µm). The cuttings with retained fluids are discharged below the water line and the mud is recirculated into the fluid system. Cuttings will typically drop out of suspension in the vicinity of the well site (as coarser materials), while the fluids, if not flocculated with the cuttings may

[2] *Volumes described are approximate and may be subject to change due to well design and operational requirements.*

[3] *Should additional respud/sidetrack activities be required, additional cuttings may be generated. However, this would be at a considerably lower volume than the per well volume provided above.*

disperse further, temporarily elevating TSS and sediment deposition.

Where NWBM is needed to drill a well section, the cuttings from the NWBM drilling fluid system will also pass through a cuttings dryer to reduce the average residual oil on cuttings for the well (only sections using NWBM) to as low as reasonably practicable, prior to discharge. In the event of SCE failures, cuttings may be discharged without having passed through the dryer; however, this will only occur for a short duration while the drill string is being moved to a safe location in the well and existing cuttings are circulated out of hole. A decision will then be made on the case for drilling ahead without the failed SCE, whilst still meeting residual OOC discharge limits. Drilling ahead while SCE breakdown assessment and repairs occur is a contingent activity subject to additional controls (**C8.5 and C8.6** below), however the standard mode of operation to ensure management of cuttings to ALARP is to treat cuttings through a dryer.

An OOC discharge limit of <6.9% on wet cuttings will be averaged over sections drilled with NWBM for the well. The estimated volume of cuttings discharged with residual NWBM is shown in **Table 12-3** for a hypothetical worst case well. Typical NWBM cuttings volumes may be around 144 m^3 (per well).

DST and Well Bore Clean-Out Fluids

Prior to installing the DST string, wells will generally be displaced from the drilling fluid system to brine. A chemical cleanout fluids train will be circulated between the two fluids, then seawater or brine circulated until operational cleanliness specifications are met. This will be in line with Woodside's Reservoir, Drilling and Completions Fluids Guideline. Brine is this typically a filtered brine with <70 NTU and/or <0.05% total suspended solids (TSS). This results in a brine and seawater discharge after this operation. Should there be clean-up brine contaminated with base oil or NWBM, it will be captured and stored on the MODU for discharge if oil concentration is <1% by volume, or returned to shore if discharge requirements cannot be met. Initial clean-up fluids (usually returned to the rig within the first few hours of circulation) which are predominantly drilling mud (concentration of mud compared to brine is a higher percentage of mud) will be discharged as per requirements in this EP or returned to shore if requirements are not met.

Drilling Muds

WBM will be operationally discharged to the marine environment at the location of the well being drilled during the Petroleum Activities Program under the following scenarios:

1. at the seabed when drilling the top hole (riser less) sections
2. below sea surface as fluid remaining on drill cuttings, after passing through the SCE (bottom hole sections, drilled with riser in place)
3. from the mud pits from a pipe below the sea surface, if the WBM cannot be re-circulated/ re-used through the drilling fluid system (due to deterioration/ contamination), re-used on the well or on another well; or stored.

NWBM are not planned for the drilling of the Achernar exploration well, however, NWMB may be used in the drilling of future wells should the offset history, geohazards assessment and borehole stability studies indicate that NWBM is required to manage well stability to safe levels.

Drilling fluids are contained within the drilling fluids circulation system. Mud pits (tanks) within this system provide capacity for the storage of drilling fluids. The mud pits are cleaned out at the completion of drilling operations. Should NWMB be used, mud pit residue may be discharged to the sea where the residue contains <1% oil volume. Where the mud pit residue exceeds 1% by volume, the residue will either be retained and disposed of onshore.

Base oil and chemicals used in WBM and NWBM are assessed in accordance with Chemical Selection and Assessment Environment Guideline.

Contingent Activities

Respud

The requirement to respud a well is overall a low likelihood event. If required, the most likely scenario is that the decision to respud is made during drilling of the top hole section of a well, and therefore the incremental increase in cuttings and mud discharges are associated with the repeat drilling of the same top hole sections for the respudded well with the same associated discharges. A respud once drilling of the bottom hole sections has commenced is far less likely given the time and effort already committed to the well. However, if this was to occur, the associated discharges would also be a repeat of the discharges as per **Table 12-3** to re-drill the same sections of the respudded well. The likelihood of respudding an exploration/appraisal well is unlikely (<10% probability).

Sidetrack

There is a varying likelihood a sidetrack will be required, depending on the scenario. **Table 12-3** has been developed to provide an overview of potential sidetrack scenarios across the project and the associated discharges if these scenarios eventuate.

Well annular fluids

Following completion of drilling, some wellbore fluids will remain in the annular spaces between casing. Upon wellhead removal, small volumes (~ 1.5 m^3) of fluid exchange between the annular spaces and the ocean may occur. The exchange will not be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater. In the unlikely event routine wellhead removal techniques are unsuccessful, this fluid exchange will happen following sufficient corrosion of the wellhead.

Impact Assessment
The identified potential impacts associated with the discharge of drill cuttings and fluids include a localised reduction in water and seabed sediment quality, and detrimental but localised changes to benthic biota (habitats and communities). A number of direct and indirect impact pathways are identified for drill cuttings and drilling fluids, being: • temporary increase in total suspended solids (TSS) in the water column • attenuation of light penetration as an indirect consequence of the elevation of TSS and the rate of sedimentation • sediment deposition to the seabed leading to the alteration of the physio-chemical composition of sediments, and burial and potential smothering effects to sessile benthic biota • potential contamination and toxicity effects to benthic and in-water biota. The six wells will be drilled in the PAA is situated in offshore waters (~127 km from nearest coastline) in water depths of ~100–129 m. The Montebello Australian Marine Park is the closest MPA to the PAA, at a distance of approximately 95 km (south south-east). The abiotic habitat in the area is likely comprised of deep soft, unconsolidated sediment seabed, which is relatively flat and featureless. Approximately 115 km^2 of the Ancient Coastline at the 125 m Depth Contour ('Ancient Coastline') KEF overlaps with the PAA, representing ~0.7% of the overall KEF. The Ancient Coastline KEF provides areas of hard substrate, within a predominant habitat of soft sediment of NWMR. Areas of hard substrate may contribute to higher diversity and enhanced species richness relative. Although the ancient coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner et al., 2009). Given the relatively small percentage of the KEF is overlapped by the PAA, and the area potentially impacted by drill cuttings represents a small proportion of the PAA, the discharge of drill cuttings is unlikely to influence the ecological value of the Ancient Coastline at 125 m Depth Contour KEF. The top hole sections drilled (riser-less) have drill cuttings and unrecoverable fluids discharged at the seabed at the well site and typically result in a localised area of sediment deposition (known as a cuttings pile) in close proximity to the well site. However, should a RMR system be implemented, such impacts are avoided due to cuttings being discharged at the sea surface. Depending on seabed current regimes, a greater spread of cuttings and muds may occur downstream from the well site. The bottom hole sections are drilled after the riser is fitted. Cuttings with unrecoverable fluids are discharged below the water line at the MODU site, resulting in drill cuttings and drilling fluids (WBMs or NWBMs) rapidly diluting, which disperse and settle through the water column. The dispersion and fate of the cuttings is determined by particle size and density of the unrecoverable fluids; therefore, the sediment particles will primarily settle in proximity to the well site with potential for localised spread downstream (depending on currents and their speed throughout the water column and seabed) (IOGP, 2016). The finer particles will remain in suspension and be transported further before settling. Top hole cuttings are highly localised and concentrated around the wellhead, while research has shown that volumes of bottom hole cuttings sharply decrease with distance from the discharge point; however, the distribution of these cuttings is generally very patchy (Nedwed, 2006; Balcom, 2012). Potential impacts from the discharge of cuttings range from the complete burial of benthic biota in the immediate vicinity of the well site due to sediment deposition (mainly top hole cuttings), smothering effects from raised sedimentation concentrations as a result of elevated Total Suspended Solids (TSS), changes to the physio-chemical properties of the seabed sediments (particle size distribution and potential for reduction in oxygen levels within the surface sediments due to organic matter degradation by aerobic bacteria) and subsequent changes to the composition of infauna communities to minor sediment loading above background and no associated ecological effects. Predicted impacts for bottom hole cuttings are generally confined to a maximum of 500 m of the discharge point (IOGP, 2016), while cuttings for top hole drilling will be much more localised. Should a CAN conductor be used, cuttings are not produced during conductor installation. *Habitats and Communities (physical impact of cuttings)* Cuttings discharged at the seabed during drilling of the top hole sections of wells will result in localised cuttings piles on the seabed surrounding the well head. Benthic organisms below this cuttings pile will be smothered; however, the cuttings piles from top hole sections are expected to be recolonised over time. Drilling fluids used for the top hole sections consist entirely of WBM. Mobile benthic fauna, such as demersal fish, may be temporarily displaced from areas where cuttings discharges accumulate. Ecological impacts are

expected to such biota is predicted when sediment deposition is equal to or greater than 6.5 mm (in thickness) (IOGP, 2016). This amount of sediment deposition is expected to be confined to within a few hundred metres around the well location. Low levels of sediment deposition away from the immediate area of the well site may occur and would represent a thin layer of settled drill cuttings which will likely be naturally reworked into surface sediment layers through bioturbation (USEPA, 2000) and will not be of a significant impact.

Furthermore, ecological impacts are not expected for mobile benthic fauna such as crabs and shrimps or pelagic and demersal fish given their mobility (IOGP, 2016). Balcom *et al*. (2012) concluded that impacts associated with the discharge of cuttings and base fluids (including synthetic based muds (NWBMs) are minimal, with impacts highly localised to the area of the discharge. Changes to benthic communities are normally not severe. Organic enrichment can occur leading to anoxic conditions in the surface sediments and a loss of infauna species that have a low tolerance to low oxygen concentrations, and to a lesser extent chemical toxicity near the well location. These impacts are highly localised with short-term recovery that may include changes in community composition with the replacement of infauna species that are hypoxia-tolerant (IOGP, 2016). Recovery of affected benthic infauna, epifauna and demersal communities is expected to occur quickly, given the short duration of sediment deposition and the widely represented benthic and demersal community composition.

Should RMR be used, the impacts of smothering to benthic habitats/fauna are reduced. Given the greater opportunity for cuttings to disperse in the water column when discharged at the sea surface, the potential for smothering of pelagic fauna is greatly reduced.

Water Quality

The discharge of drill cuttings and unrecoverable fluids is expected to increase turbidity and total suspended sediment levels in the water column, leading to an increased sedimentation rate above ambient levels associated with the settlement of suspended sediment particles in close proximity to the seabed or below sea surface, depending on location of discharge. Drill cuttings discharge is generally intermittent and of short duration (over a total period of approximately 75 days) during the drilling of a well. Nelson *et al.* (2016) identified <10 mg/L as no effect or sub lethal minimal effect concentration. Given the generally low concentration of total suspended solids (TSS) (due to rapid dispersion from the well site), the offshore open ocean site in conjunction with rapid dispersion of sediment and the short period of intermittent discharge, the plume is not expected to have more than a very highly localised potential area of ecological impact and it is not predicted to impact productivity of the water column. Furthermore, there are no likely impacts expected for pelagic fauna. While very high concentrations of suspended sediments have been shown to result in mortality of pelagic animals (>1830 mg/L), such concentrations do not occur as a result of drill cuttings discharges (IOGP, 2016). In addition, fish are likely to move away when elevated TSS concentrations are detected while air breathing megafauna such as cetaceans and turtles are not expected to be in direct contact with TSS plume given its proximity to the MODU. Any potential contact would be of a short duration given the rapid dispersion of the plume and the expected transient movement of megafauna in this offshore area. Light dependent benthic primary producer habitats are not located with the PAA.

Given the composition and wider representation of the expected benthic communities in the vicinity of the PAA, the ecological impacts are considered to be slight and short-term.

Drill cuttings discharged at the seabed and settlement of cuttings may, depending on final location of wells, occur on the Ancient Coastline KEF. Given the benthic habitats characteristic of the KEF, likely soft sediment with potential for areas of hard substrate and associated infauna, and the wider representation of the KEF (>99%) outside of the PAA, any potential ecological impacts will be localised and are not considered significant. Additionally the values of the Ancient Coastline KEF (e.g. enhanced upwelling) will not be impacted by the settlement of cuttings.

Sediment Quality and Habitats and Communities (contamination from and toxicological effects of drilling muds)

Indicative components of the WBM system outlined in **Section 3.7.2** have a low toxicity. Bentonite and a chemical from the family of XC Polymer's (Xanthan Gum or similar) are listed as 'E' category fluids under the OCNS and considered to 'pose little or no risk to the environment' (PLONOR). These metals are present primarily as insoluble mineralised salts and consequently are not released in significant amounts to the pore water of marine sediments and have low bioavailability to those benthic fauna which may come into contact with the discharged barite (Crecelius *et al*., 2007; Neff, 2008).

The XC Polymer and bentonite sweeps have very low toxicities and are considered by OSPAR to be PLONOR to the environment. They may; however, cause physical damage to benthic organisms by abrasion or clogging, or through changes in sediment texture that can inhibit the settlement of planktonic polychaete and mollusc larvae (Swan *et al*., 1994). However, these impacts are not expected to be significant due to the rapid biodegradation and dispersion of WBM drilling fluids (Terrens *et al*., 1998) and no significant habitats/biota are considered to be present in the PAA. The dilution of solid elements of the WBM into substrate largely depends on the energy level of the local environment and the 'mixing' that takes place, but is expected to occur rapidly following release (especially with WBM). The low sensitivity of the benthic communities/habitats combined with the low toxicity of WBM and low physical impacts affirm that any significant impact is considered unlikely.

Base fluids for NWBM are designed to be biodegradable in offshore marine sediments. Biodegradation can result in a low oxygen (anoxic) environment resulting in changes in benthic community structure. However, this is dependent on the bioavailability of the base fluid. Species sensitive to anoxic environments are eliminated and replaced by tolerant and opportunistic species, resulting in decreased species diversity, but the number of individuals often increases (Neff *et al*., 2000). NWBM are designed to be low in toxicity and are not readily bioavailable, based on their physical/chemical properties, for bioaccumulation to infauna and epifauna.

Furthermore, the combination of low toxicity and rapid dilution of unrecoverable NWBMs discharged in association with drill cuttings are of little risk of direct toxicity to water-column biota (Neff *et al*., 2000). A small quantity of WBM and NWBM residue may be discharged at the sea surface during cleaning of mud pit (<1%), typically at the conclusion of drilling activities, or when changing between mud types. Nedwed et al. (2006) found that depth is an important factor for concentrations of NWBM on cuttings, where cuttings which had a great distance to reach the seabed (950 m) had significantly lower concentrations, suggesting that loss of base fluid during settling acted to significantly reduce chemical effects from discharges. The study concluded to find that NWMD discharged in deep water posed very limited environmental impacts (from analysis of difference in benthic fauna between pre- and post-drilling samples (Nedwed *et al*., 2006). This discharge is expected to dilute rapidly, with potential impacts to the environment considered to be a local, temporary decrease in water quality.

The low sensitivity of the benthic communities/habitats within and in the vicinity of the PAA, combined with the low toxicity of WBM and NWBMs, no bulk discharges of NWBM and the highly localised nature and scale of predicted physical impacts to seabed biota affirm that any significant impact is considered likely but of a slight environmental consequence.

Cumulative Impacts

Given the Petroleum Activities Program includes the drilling of six wells, there is the potential for cumulative disturbance to marine sediment quality and benthic communities to occur. The cuttings and drilling fluids discharges from each of the wells will accumulate within the receiving environment. The only existing wellhead in the PAA was drilled in the 1970s and therefore it is expected that the benthic habitat communities have fully recovered since then, posing no risk for significant cumulative impacts from historical wells. Therefore, cumulative impacts are expected to be limited to the Petroleum Activities Program.

Given the size of the PAA and the number of wells to be drilled, it is possible that overlap of Operational Areas will occur. When considering deposition of sediments from each drilling activity, deposition at a thickness of greater than 6.5 mm is limited to within a distance of a hundred metres, although this is dependent on the nature of the cuttings, and the water depth and currents of the receiving environment (IOGP, 2016). Wells associated with the Petroleum Activities Program are likely to be spaced more than a few hundred metres apart and therefore areas where ecological impacts are expected, sedimentation greater than 6.5 mm, are not expected to overlap. However cumulative impacts from the appraisal wells may occur if drilled within a few hundred metres of an exploration well. In the event Woodside drills wells that overlap cutting field impacts are anticipated to be minimal, considering the observed limited benthic biota within the PAA.

No cumulative to water quality are expected to occur since discharged sediments are predicted to settle in between the drilling activities for each well and no concurrent drilling will occur.

<u>*Well Annular Fluids*</u>

The non-instantaneous nature of the release of the well annular fluids is expected to result in rapid dilution to a no-effect concentration within meters of the release location.

Summary of Potential Impacts to environmental values(s)

Given the adopted controls, it is considered that the drill cutting and drilling muds discharges described will not result in a potential impact greater than localised burial and smothering of benthic habitats and

slight/short term effects to water quality (e.g. turbidity increase) (i.e. Environment Impact - E).
Summary of Control Measures
• Chemical Selection and Assessment Environment Guideline for selection of drilling, completions, cementing and sub-sea control fluids and additives. • Written NWBM justification process followed. • Environmental Performance Standards Procedure which restricts overboard bulk discharge of NWBM. • Bulk operational discharges conducted under MODU's permit to Work (PTW) system (to operate discharge valves/pumps). • While drilling with NWBM – in event of solids control equipment failure including auger, initial action should include – cease drilling and assess feasibility to fix SCE or drill ahead until next practicable opportunity to retrieve string. • If discharging cuttings during dryer or auger failure, measurement of OCC to occur more frequently from shakers. • Mud pit wash residue will only be discharged if less than 1% by volume is oil content. • WBM Drill cuttings returned to the MODU will be processed using SCE allowing reuse of mud, where possible, prior to discharge. All drilling with riser in place will be undertaken using SCE to limit discharge of mud on cuttings. • Discharge of cuttings below the water line in accordance with the Engineering Standard – Rig Equipment. • Solids Control Equipment used to treat NWBM cuttings and reduce the average oil on cuttings for the well to 6.9% wt/wt or less on wet cuttings prior to discharge.

Routine and Non-routine Discharges to the Marine Environment: Cementing, Subsea Fluids and Unused Bulk Products

Impacts and Risks Evaluation Summary														
Source of Impact	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Routine discharge of cement, cement cuttings, cementing fluids, subsea fluids (e.g. BOP control fluids and well suspension fluids) and other down-well products to the seabed and the marine environment.		X	X		X			A	E	-	-	LCS GP PJ	Broadly Acceptable	EPO 8

Description of Source of Impact

Cementing Fluids and Cement

Cementing fluids may require discharge to the marine environment under various scenarios.

When cementing the conductor and surface casings after top-hole sections of the well have been drilled, cement must be circulated to the seabed to ensure structural integrity of the well. Excess cement is pumped to ensure structural integrity is achieved.

If the hole is completely in-gauge and there are no downhole losses while pumping the cement, a maximum volume of 113 m^3 per well is estimated to be circulated to the seafloor at the well location, which forms a thin concrete film on the seabed in close proximity to the well.

After each cement job, left over cement slurry in the cement pump unit and the surface lines is flushed and discharged to the sea to prevent clogging of the lines and equipment. This is estimated at approximately 175 m^3 per well (based on up to 7 cement jobs per well x 25 bbls discharged per job). The requirement to respud a well is overall a low likelihood event but could result in additional cement jobs.

Cement spacers can be used as part of the cementing process, within the well casing, to assist with cleaning of the casing sections prior to cement flow through. The spacers may consist of either seawater or a mixture of seawater and dye. The dye is used to provide a pre-indicator of cement overflow to the seabed surface, to ensure adequate cement height.

Excess cement (dry bulk, after well operations are completed) will either be: used for subsequent wells; provided to the next operator at the end of the drilling program (as it remains on the rig); or if these options aren't practicable discharged to the marine environment as dry bulk or as a slurry.

Upon arrival on location at the Operational Area, the rig may be required to perform a cement unit test, or 'dummy cement job'. Discharges from the test are made through the usual cement unit discharge line, which may be up to 10 m above the sea level, and occur as a cement slurry. The slurry is usually a mix of cement and water; however, may sometimes contain stabilisers or chemical additives.

Subsea Fluids BOP Control Fluids

Subsea Fluids likely to be released during drilling are BOP controls fluids. The BOP is required to be regularly function tested when subsea, as defined by legislative requirements. The BOP is function tested during assembly and maintenance and during operation on the seabed. As part of this testing, small volumes of BOP control fluid (generally consisting of water mixed with a glycol based detergent or equivalent water based anti-corrosive additive) is released to the marine environment. The hydraulic control fluid will be/will be similar to Stack-Magic (commercial name), which is biodegradable. For the Achernar exploration well exploration well (used to inform the impact assessment) it has been determined that the BOP will be function tested every 7 days (when a pressure test is not occurring) and pressure tested a minimum of every 21 days as per API 53 (approximately 14 releases over drilling of the Achernar exploration well exploration well). This will result in discharges of approximately 68 L stack-magic per test.

Other DOWN-WELL PRODUCTS

Additional products such as barite and bentonite may be discharged in bulk during or at the end of the activity if they cannot be reused or taken back to shore. Use and discharge of all chemicals will be done so in line with Woodside's Chemical Selection and Assessment Environment Guideline. Discharge may be in the form of dry bulk or as a slurry; however, discharges will not be contaminated with hydrocarbons.

Impact Assessment

Potential Impacts to Water Quality, Sediment Quality and Other Habitats and Communities

Pelagic and benthic habitats in the PAA are considered to be of low sensitivity (no known significant benthic habitat or infauna habitat). Although the Ancient coastline at 125 m depth contour KEF overlaps with the PAA, the values and sensitivities of this KEF occur on a broad scale outside (99%) of the PAA. Coupled with the low toxicity of the fluids to be used for the Petroleum Activities Program, the likelihood of any significant impact to marine biota is considered to be low.

Cement and Cement Cuttings

Impacts of cement and cement cuttings on the marine environment are associated mainly with smothering of surrounding benthic and/or infauna communities. Cement is the most common material currently used in artificial reefs around the world (OSPAR, 2010) and is not expected to pose any toxicological impacts to receptors from leaching or direct contact. A minimum cement volume is required to be stored on the MODU for use in well control and plug and abandon activities. While cement volumes are calculated prior to use to minimise excess, the requirement for additional volumes on the MODU means some cement may require discharge if options for reuse on other wells is not possible. Discharge if excess cement may occur as dry bulk or as a slurry. Dry bulk has the potentially to disperse across a wider area, but at lower concentration, compared to slurry which would have a greater tendency to settle on the seafloor closer to the well location. In either case, discharges are not expected to widely disperse before settling on the seabed. The impact of cement discharge at the seabed will therefore, be limited to any surrounding benthic and/or infauna communities, in a small localised area immediately around the well and likely within the area previously impacted by drill cuttings.

Cementing Fluids, Subsea Fluids (BOP Control Fluids and Well Suspension Fluids) and Other Down-Well Products

All chemicals that may be operationally released or discharged to the marine environment are required to be selected and approved as per the Chemical Selection and Assessment Environment. Therefore, any chemicals selected and potentially released are expected to be of low toxicity and biodegradable. Additionally, where cements have been mixed in excess and cannot be reused or returned to shore these will be turned into a slurry. As chemicals have initially been chosen based on the environmental performance and based on an ALARP assessment, additional dilution prior to discharge further reduces the environment impact to water quality, sediment quality and marine benthic and/or infauna communities are reduced. Given the minor quantities of routine and non-routine planned discharges, short discharge durations and the low toxicity and high dispersion in the open, offshore environment, any impacts on the marine environment are expected to be slight and localised.

Given the highly localised nature of these discharges and potential impacts, cumulative impacts to marine biota, water quality and sediments are not expected.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that the routine discharge of cement, cementing fluid, subsea fluid and other down-well products described will not result in a potential impact greater than localised, slight and short term impacts to infauna and benthic communities, water quality and marine sediment (but not affecting ecosystems function). (i.e. Environment Impact - E).

Summary of Control Measures

- Chemical Selection and Assessment Environment Guideline for drilling, completions, fluids.
- Bulk operational discharges conducted under MODU's permit to Work (PTW) system (to operate discharge valves/pumps).

Routine Atmospheric Emissions: Fuel Combustion, Flaring, Incineration and Venting

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Internal combustion engines and incinerators on MODU, ISV and support vessels.				X				A	F	-	-	LCS GP PJ	Broadly acceptable	EPO 9
Flaring during DST.				X				A	F	-	-	LCS GP PJ		EPO 10
Unplanned venting of gas.				X				A	F	-	-	LCS GP PJ		EPO 11

Description of Source of Impact

Atmospheric emissions will be generated by the project vessels from internal combustion engines (including all equipment and generators) and incineration activities (including onboard incinerators) during the Petroleum Activities Program. Emissions will include SO_2, NO_x, ozone depleting substances, CO_2, particulates and Volatile Organic Compounds (VOCs).

Woodside may undertake drill stem testing (DST) on any of the planned wells. DST will flow hydrocarbons from the well to the MODU, which will be flared. The volumes of hydrocarbons flared are unknown and subject to operational requirements. To inform the impact assessment, Woodside has estimated that drill stem testing may require intermittent flaring for up to 20 days, up to 900 million standard cubic feet of hydrocarbons flared per well. These estimates are based on Woodside's operational experience and are considered applicable for the Petroleum Activities Program.

During drilling of the well, a kick may occur. A kick is an undesirable influx of formation fluid into the wellbore. The resultant effect would be a release of a small volume of greenhouse gases via the degasser to the atmosphere during well control operations, known as 'venting'. Venting is required to ensure well integrity is maintained in the event of a kick.

Impact Assessment
Fuel combustion, flaring and incineration have the potential to result in localised, temporary reduction in air quality. Potential impacts include a localised reduction in air quality, generation of dark smoke and contribution to greenhouse gas emissions. Given the short duration and exposed location of the MODU, ISVs and support vessels (which will lead to the rapid dispersion of the low volumes of atmospheric emissions), the potential impacts are expected to have no lasting effect, with no cumulative impacts when considered in the context of existing or future oil and gas operations in the region. Venting may result in localised and temporary reduction in air quality as the gas vents to the atmosphere, and localised and temporary contribution to greenhouse gas emissions. There is potential for human health effects for workers in the immediate vicinity of atmospheric emissions. However, the closest sensitive residential receptor is the town of Dampier, approximately 127 km south south-east of the PAA; therefore, any risks associated with off-site human health effects are negligible beyond the immediate zone of release and dispersion. Given the short duration and isolated location of the Petroleum Activities Program (which will lead to the rapid dispersion of the low volumes of atmospheric emissions) the potential impacts are expected to be minor.
Summary of Potential Impacts to environmental values(s)
Given the adopted controls, it is considered that fuel combustion, flaring, incineration and venting emissions will not result in a potential impact greater than a temporary decrease in local air quality and /or water quality standards with no lasting effect and no significant impact to environmental receptors. (i.e. Environment Impact - F)
Summary of Control Measures

• Marine Order 97 (Marine Pollution Prevention – Air Pollution).
• *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011*: Accepted Well Operations Management Plan (WOMP) and application to drill.
• The Well Acceptance Criteria Procedure details the as-built checks that shall be completed during well operations to establish a minimum acceptable standard of well integrity is achieved.
• The Well Blowout Contingency Planning Procedure details specifications for well design to assess the feasibility of performing a well kill operation.
• Maintain flare to maximise efficiency of combustion and minimise venting.
• Subsea BOP specification and function testing is undertaken in accordance with internal Woodside Standards and international requirements:
  - Original Equipment Manufacturer (OEM) Standards
  - Engineering Standard – Rig Equipment (Woodside Doc No. W1000SD7188648)
  - Drilling and Completions – Well Control Manual (Woodside Doc No. DC0000PD101151)
  - API Standard 53 4th Edition.
• Drilling and Completions – Well Control Manual specifies the process to be undertaken to calculate, update and monitor kick tolerance for use in well design and while drilling.
• Contractor Well Control Bridging Document (WCBD) covers the equipment and procedures for preventing and handling a well kick.

Routine Light Emissions: External Lighting on MODU, ISV and Support Vessels

Impacts and Risks Evaluation Summary														
Source of Impact	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
External light emissions on-board MODU, ISV and project vessels.						X		A	F	-	-	LCS GP PJ	Broadly acceptable	N/A

Description of Source of Impact

The MODU, ISVs and support vessels will have external lighting to facilitate navigation and safe operations at night throughout the Petroleum Activities Program. External light emissions from the MODU, ISV and support vessels are typically managed to maintain good night vision for crew members.

Lighting on the MODU is used to allow safe operations during night hours, as well as to communicate the MODU's presence and activities to other marine users (i.e. navigation lights). Lighting is required for the safe operation of the MODU and cannot reasonably be eliminated. Note that flaring, which is a relatively bright light source, may occur during DST.

External lighting is located over the entire MODU, with most external lighting directed towards working areas such as the main deck, pipe rack and drill floor. These areas are typically lower than 20 m above sea level when the MODU is on station. The highest point on the MODU is the top of the derrick, which is typically approximately 50 m above sea level. The distance to the horizon at which components of the MODU will be directly visible can be estimated using the formula below:

$$horizon\ distance = 3.57 \times \sqrt{height}$$

Where horizon distance is the distance to the horizon at sea level in kilometres and height is the height above sea level of the light source in metres. Using this formula, the approximate distances at which various MODU components (and associated light sources) will be visible at sea level are:

- Main deck (~20 m above sea level): approximately 16 km from MODU
- Derrick top (~50 m above sea level): approximately 25 km from MODU.

Impact Assessment

Light emissions can affect fauna in two main ways:

- *Behaviour*: Many organisms are adapted to natural levels of lighting and the natural changes associated with the day and night cycle as well as the night time phase of the moon. Artificial lighting has the potential to create a constant level of light at night that can override these natural levels and cycles.
- *Orientation*: Species such as marine turtles and birds may also use lighting from natural sources to orient themselves in a certain direction at night. In instances where an artificial light source is brighter than a natural source, the artificial light may act to override natural cues leading to disorientation.

The fauna within the PAA are predominantly pelagic fish and zooplankton, with a low abundance of transient species such as marine turtles, whale sharks, whales and migratory sea birds. There is no known critical habitat within the PAA for EPBC listed species, although there is a distribution BIA for pygmy blue whales and a foraging BIA for whale sharks, which are not expected to be impacted by above surface light emissions. Given the fauna expected to occur within the PAA, impacts from light emissions are considered to be highly unlikely.

Marine Turtles – Adults

Artificial lighting may affect the location that turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon *et al*., 1995a, 1995b; Salmon and Witherington, 1995). Such lighting is typically from residential and industrial development overlapping the coastline, rather than offshore from nesting beaches. The PAA does not contain any known critical habitat for any species of marine turtle (nearest landfall (islands offshore the Dampier Peninsula) are located approximately 85 km from PAA) and the nearest turtle BIA is 8 km from the PAA. It is acknowledged that marine turtles may be present transiting the PAA in low densities.

Migratory Birds

The PAA may be occasionally visited by migratory and oceanic birds but does not contain any emergent land that could be utilised as roosting or nesting habitat and contains no known critical habitats for any species. However, the PAA partly overlaps breeding (August to April) and foraging BIAs for the wedge-tailed shearwater.

Seabird surveys over the Northwest Shelf Province, south and southeast of the PAA, have noted that seabird distributions in tropical waters were generally patchy, except near islands (Dunlop *et al*., 1988). Given the PAA lies further offshore from this area, with no islands in close proximity, seabirds are likely to only transit over the PAA when travelling between emergent land and important habitats. Migratory shorebirds may be present in, or fly through the region between July and December and again between March and April as they complete migrations between Australia and offshore locations (DoE, 2015b).The risk associated with collision from seabirds attracted to the light is considered to be low given the low numbers expected to transit the area and that there is no critical habitat for these species within the PAA, as well as the slow moving speeds associated with the MODU, ISV, and support vessels.

Fish

Lighting from the presence of a vessel may result in the localised aggregation of fish below the vessel. These aggregations of fish are considered localised and temporary and any long term changes to fish species composition or abundance is considered highly unlikely. This localised increase in fish extends to those comprising the whale shark's diet. However, given that a large proportion of the diet comprises krill and other planktonic larvae, it is unlikely that a light source will lead to a significant increase in whale shark abundance in the vicinity of the MODU and vessels.

Summary of Potential Impacts to environmental values(s)

Light emissions from the MODU, ISV and support vessels will not result in an impact greater than localised and temporary disturbance to fauna in the vicinity of the PAA, with no lasting effect. (i.e. Environment Impact – F).

Summary of Control Measures

- The potential impacts and risks from light emissions are deemed to be ALARP in its current risk state. No reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice.

UNPLANNED ACTIVITIES (ACCIDENTS / INCIDENTS / EMERGENCY SITUATIONS)

Accidental Hydrocarbon Release: Loss of Well Integrity

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Loss of hydrocarbons to marine environment due to loss of well integrity.		X	X	X	X	X	X	C	B	2	H	LCS GP PJ RBA CS SV	Acceptable if ALARP	EPO 12

Description of Source of Risk

Loss of Well Integrity – Background

A loss of well integrity is an uncontrolled release of reservoir hydrocarbon or other well fluids to the marine environment, resulting from an over-pressured reservoir. Woodside has identified a blowout as the scenario with the worst case credible environmental outcome as a result of loss of well integrity. A blowout is an incident where formation fluid flows out of the well or between formation layers after all the predefined technical well barriers (e.g. the BOP) or activation of the same have failed.

Industry Experience

A risk assessment by AMSA of oil spills in Australian ports and waters (Det Norske Veritas, 2011) concluded that:

- overall national exceedance frequency for oil spills from offshore drilling in Australia is 0.033 for spills >1 tonne/year decreasing to 0.008 for spills >100 tonnes/year (Det Norske Veritas, 2011)
- blow-out probability for an exploration well was estimated to be 3.1 x 10-4 per well (Det Norske Veritas, 2011). This is based on data from the Gulf of Mexico, United Kingdom and Norway from 1980–2004, including wells that had BOPs installed
- probability of a blow-out from an oil exploration well is 2.5 x 10-4 (0.00025, or 0.025%) (International Association of Oil and Gas Producers, 2010).

Woodside has a good history of implementing industry standard practice in well design and construction. In the company's 60 year history, it has not experienced any well integrity events that have resulted in significant releases or significant environmental impacts.

Therefore, in accordance with the Woodside Risk Matrix, a loss of well integrity and resulting blowout event corresponds to an 'unlikely' event as it has occurred many times in the industry, but not in the Company.

Drilling Timeframe

Drilling is scheduled to occur throughout the year (all seasons), to provide operational flexibility for requirements and schedule changes and vessel/MODU availability.

Credible Scenario – Loss of Well Control

The Petroleum Activities Program consists of the drilling of six wells (up to three exploration wells and three appraisal wells). Detailed planning and scheduling of the Achernar exploration well is currently being undertaken, with the remaining exploration/appraisal wells to be planned pending outcomes of Achernar or as required under Permit Area requirements.

A loss of well integrity could result in a loss of containment at any of these six wells. The location of the proposed Achernar exploration well was chosen as the release site in the modelling since this is a representative location in the PAA in which one well could intersect two formations resulting in the worst case flow rates, in terms of volume, compared to the rest of the PAA.

Given the unconfirmed hydrocarbon type, for Achernar a well design that reduces flow rates is intended to reduce the complexity of well kill operations The oil spill scenarios, were modelled based on the Achernar exploration well design (maximum volume that could be released from any well drilled under this EP. Since the hydrocarbon type is unknown, these scenarios ~~s~~ were modelled for both crude and condensate (details of analogues provided below), resulting in two credible spill scenarios:

1. Achernar exploration well – crude.
2. Achernar exploration well – condensate.

The volumes released and the spatial extent of the ZoC of the worst credible spill scenarios are considered in the impact assessment below.

When calculating the worst case spill duration, Woodside uses a 77 day base case, however, this base case duration may not be representative to all situations. When assessing the applicability Woodside considers additional factors such as remoteness of the well location, well characteristics including TVD and relief well drill time. This may result in timeframes greater than 77 days (e.g. Woodside's Swell and Ferrand wells) or a reduction.

For wells to be in the PAA, Woodside identified the duration of the credible spill scenarios for a well blowout to be an uncontrolled surface release for five days, when the MODU would provide a conduit to the surface for the uncontrolled flow, followed by a 51 day uncontrolled seabed release as the MODU would no longer be present to provide a conduit.

The MODU would no longer be present after five days for the following reasons:

- In a non-explosion scenario, the MODU is likely to be moved off location as soon as is practicable to prevent escalation and further harm to personnel.
- In an explosion scenario, the MODU is expected to sink due to an anticipated compromise in structural integrity and stability after a period of time. The most recent example of a similar scenario is the Deepwater Horizon incident, when the semi-submersible MODU sank after 36 hours following the loss of well control in the Gulf of Mexico in April 2010.

Woodside has assessed the DWH (and as a result 5 days) a suitable blowout scenario as:

- It is the most recent significant event of this nature in the industry
- The Deepwater Horizon is comparable in size, weight and capability to the MODUs that will conduct well construction operations in WA-28-P
- Studies of the North Sea and US GoM OCS events support that the majority of blowout durations are less than 5 days (Holland, 1997).

The 56 day release duration assumes that the maximum depth of the hydrocarbon reservoir would be open and takes into account the estimated time to drill a relief well under the Mutual Aid Memorandum of Understanding (MoU). For each EP well loss of containment scenario, Woodside assesses whether the standard 77 day release usually modelled is most appropriate, based on the timeframes:

- mobilisation of relief MODU: 21 days
- relief well drill time: 42 days
- intersect and kill: 14 days.

For wells with a shallower TVD, or that are less remote, the 77 day response time can be justifiably reduced. In the case of the wells to be drilled in the PAA under this EP, the relief well drill time has been determined at 21 days reducing the overall spill duration to 56 days.

A number of Woodside procedures were followed in order to identify credible spill scenarios, including spill duration. The process followed is outlined in **Figure 12-1** with a breakdown of timeframes and justification for the reduced relief well drill time provided in **Table 12-4.**

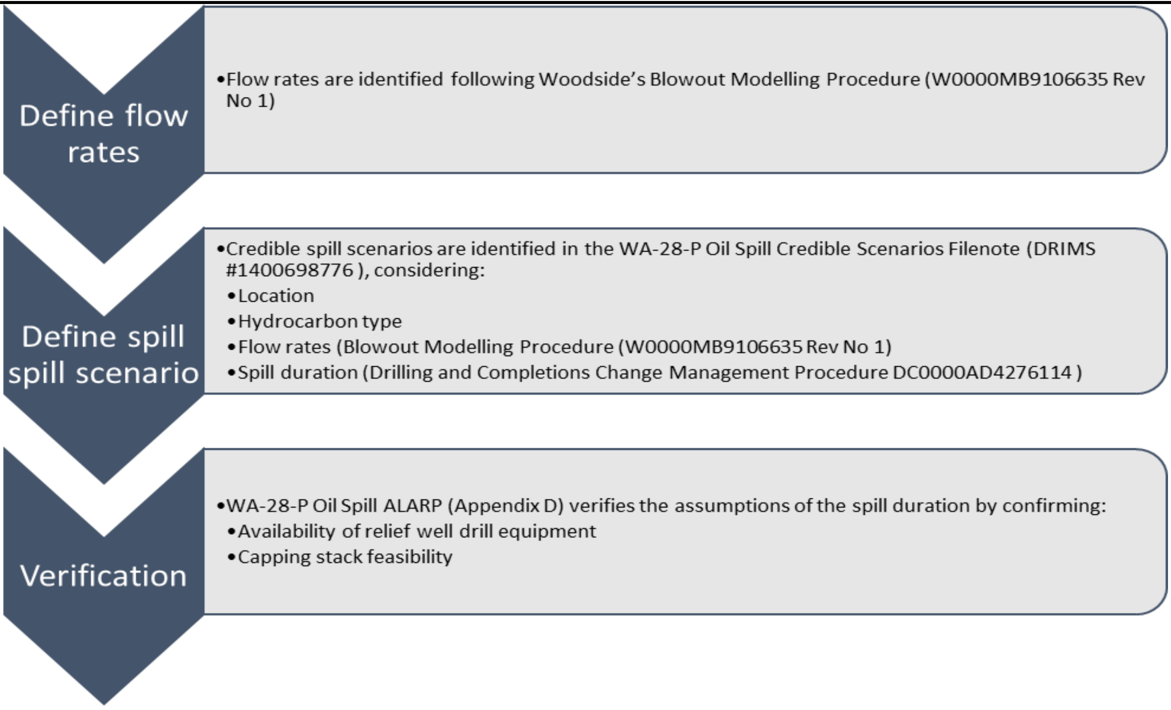

Figure 12-1: Credible oil spill scenario identification process

Table 12-4: Relief well drill times

Phase	Description	Justification	Time for completion (days)
Mobilisation	Sourcing a MODU though APPEA MoU and mobilisation	The default mobilisation duration (21 days) specified in the Woodside Blowout Modelling Procedure has not been altered. There is nothing specific pertaining to the WA-28-P wells which would justify changing this duration. Access to a MODU to drill the relief well would be via the APPEA MoU for mutual aid which is currently in place.	21
Drill relief well	Run anchors and prepare to spud	The 21 day duration to drill the relief well to 2400 m MD was calculated based on the average actual duration of relevant offset development wells. The final subset of offset wells selected included recent NWS, deviated, development wells drilled by Woodside. The average duration of these offset wells was calculated on a drill to depth of 2400 mMD to reflect the total planned relief well depth. The well duration assumptions were then peer reviewed. Woodside's D&C management of change procedure was then followed to assess the impact of the change in well duration.	3.9
	Drill 42" hole		0.4
	Run LPWHH w/36" conductor		1.5
	Drill 17-1/2" hole		5.3
	Run 9-5/8" casing		2.2
	Run BOP stack		2.1
	Drill 8.5" hole to ~2400 mD		2.1
	Run 9-5/8" liner		3.5

Intersect and kill	Relief well intersects uncontrolled well, kills well ceasing release of hydrocarbons	The default duration to intersect the blowout well and perform the dynamic well kill specified in the Woodside Blowout Modelling Procedure has not been altered. There is nothing specific pertaining to the WA-28-P wells which would justify altering this duration.	14
Total days			**56**

It should be noted that the integrity of the wellbore is not affected in the highly unlikely event that the wellhead remains in-situ. Furthermore, if the wellhead is damaged, it is not credible for the reservoir to release hydrocarbons as the well will be abandoned in accordance with the Suspension and Abandonment Procedure and the Well Barrier Procedure.

Blowout Volume

Woodside has determined that the worst case credible total release for a loss of well control in the PAA was:

- ~1,057,312 m^3 of crude, or,
- ~268, 980 m^3 of condensate.

Quantitative Spill Risk Assessment – Loss of Well Control Crude Scenario

Spill modelling was undertaken by RPS, on behalf of Woodside, to determine the fate of hydrocarbon released for the 56 day crude blowout scenario at the Achernar well location, based on the assumptions in **Table 12-5**. RPS carried out the modelling based on a volume of ~1, 057 312 m^3.

Table 12-5: Summary of modelled credible scenario – well blowout

	Loss of well integrity
Total discharge[4] at surface	5 days 101, 173 m^3
Total discharge at seabed	51 days 956, 139 m^3
Water depth	122 m
Fluid	Egret-3

Hydrocarbon Characteristics

An analogue fluid chosen was Egret-3 medium crude and (API 37) contains a relatively high proportion (~24% by mass) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. Characteristics of Egret-3 Medium Crude were specified from data supplied by Woodside, and the resultant summary data is provided in **Table 12-6**.

Table 12-6: Egret-3 Medium Crude characteristics

Oil Type	Density (g/cm^3)	Wax Content (% wt)	Viscosity (cP) [at 21°C]	Component	Volatile (%)	Semi-Volatile (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
				Boiling point (°C)	<180 C4 to C10	180–265 C11 to C15	265–380 C16 to C20	>380 >C20	Of whole oil <380 BP
Egret-3 medium crude	0.8386	<5	3.18	% of total	23.3	30.1	22.7	23.9	17.2
				% aromatics	5.3	6.8	5.1	-	-

4 The discharge volumes in this table are predicted using reservoir modelling software packages that take into account a number of factors (well design, reservoir properties and environmental conditions (e.g. water depth, temperature and pressure) to provide a production profile over the oil spill modelling period.

Egret-3 has low asphaltene content (<1%) and low wax content <5% wt, indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle.

A series of model weather tests were conducted to illustrate the potential behaviour of Egret-3 Medium Crude, to idealised and representative environmental conditions:

- Instantaneous release (1-hour discharge) at a discharge rate of 50 m^3/hr under variable wind conditions (4-19 knots, drawn from representative data files), assuming low seasonal water temperature (27 °C) and average air temperature (25 °C). Slick also subject to ambient tidal and drift currents.

Weathering processes under realistic variable wind conditions are illustrated in the example mass balance weathering graph for a discrete spill of 50 m^3 of Egret-3 crude released at the surface (**Figure 12-2**). The variable wind case is accurate for the wind speeds recorded in the region, the average wind speed year round is between 5-10 m/s, reaching 10-15 m/s during summer months. The results for the variable-wind case indicate very little oil mass predicted to persist on the sea surface (<1% after 7 days). This is largely due to wind generating significant entrainment events, with up to 45% of the oil mass becoming entrained when the wind speed reaches 8 m/s in the simulation.

The stochastic graph in **Figure 12-2** demonstrates that approximately 50% of the released hydrocarbons would be expected to evaporate within the first 24 hours. Approximately 45% is expected to entrain within 72 hours, with approximately 5% expected to dissolve in the same time period, resulting in very little floating hydrocarbons on the surface after the first five days of release. Soluble aromatic hydrocarbons contribute approximately 17.2% by mass of the whole oil, with a significant proportion (5.1%) in the C16-C20 range of hydrocarbons. These compounds will evaporate slowly, resulting in the potential for dissolution of a proportion of them into the water

Furthermore, **Figure 12-3** represents the proportional mass balance plot with the gross weathering and fate of Egret-3 Medium Crude over the 56 day life of the release from the Achernar-1 well. The weathering plot is generated from the deterministic modelling run which presented the highest volume of hydrocarbon accumulated across all shorelines from the stochastic modelling. This weathering information accounts for the full release volume and duration driven by the time the hydrocarbon is above the reported threshold. The results depict a range of wind speed and wind directions which impact on the weathering of the hydrocarbon. For this deterministic run, less entrainment and evaporation occurs compared to the stochastic weathering simulation above. This is due to the decrease in wind speed over the life of the deterministic run, with wind speeds generally below 8 m/s. This deterministic run depicts the balance between wind speeds and direction to allow hydrocarbon to travel maximum distance before entrainment resulting in the worst case credible scenario for accumulated hydrocarbons ashore. Further discussion on the use of deterministic modelling to inform response arrangements is found in Section 2.2.2 of the WA-28-P Oil Spill Preparedness and Response Mitigation Assessment (**Appendix D** of EP).

For simplicity, the Egret-3 analogues will be referred to as ‘crude’ from hereon in.

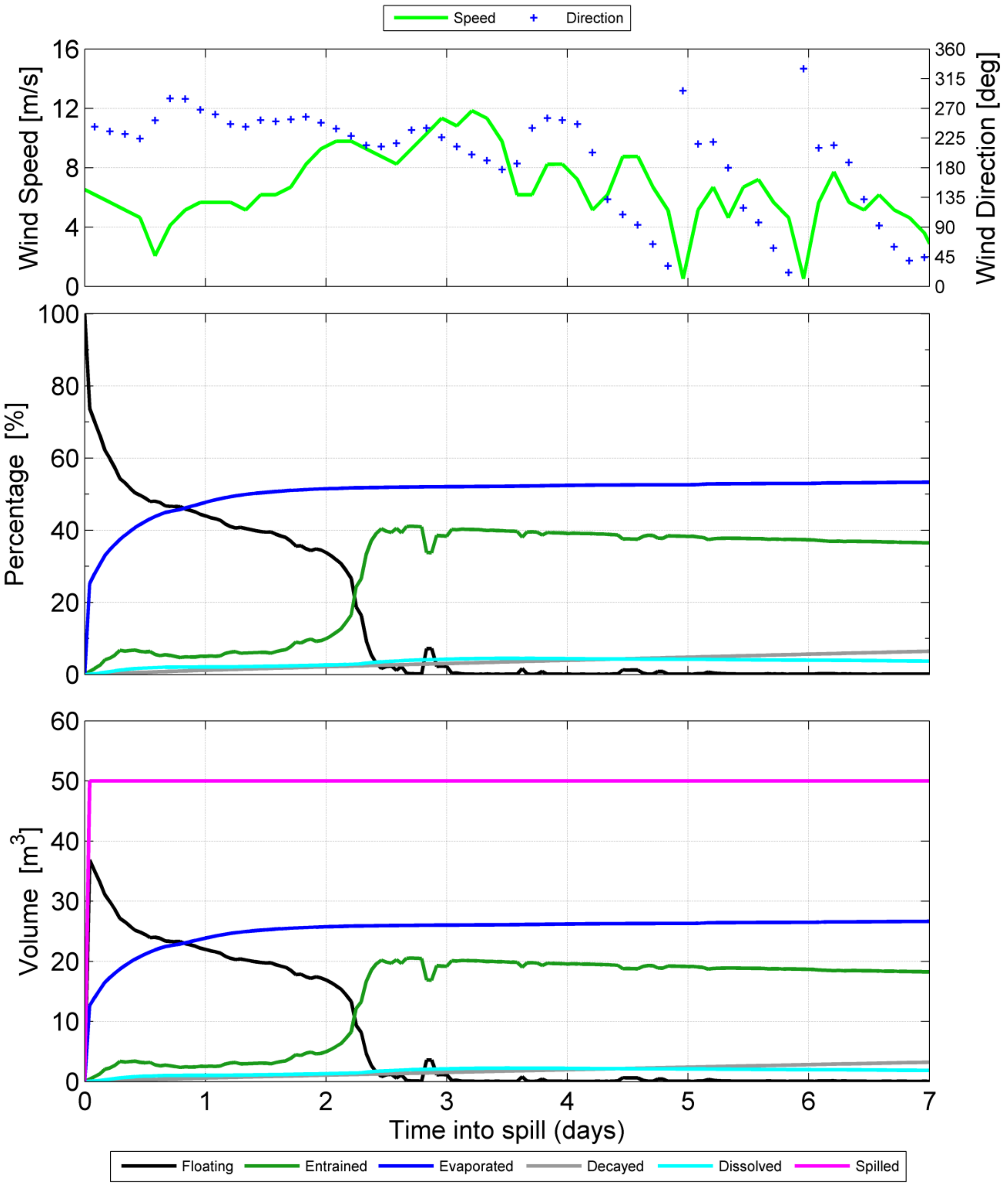

Figure 12-2: Proportional mass balance plot representing the weathering of 50 m^3 from a surface spill of Egret-3 medium crude

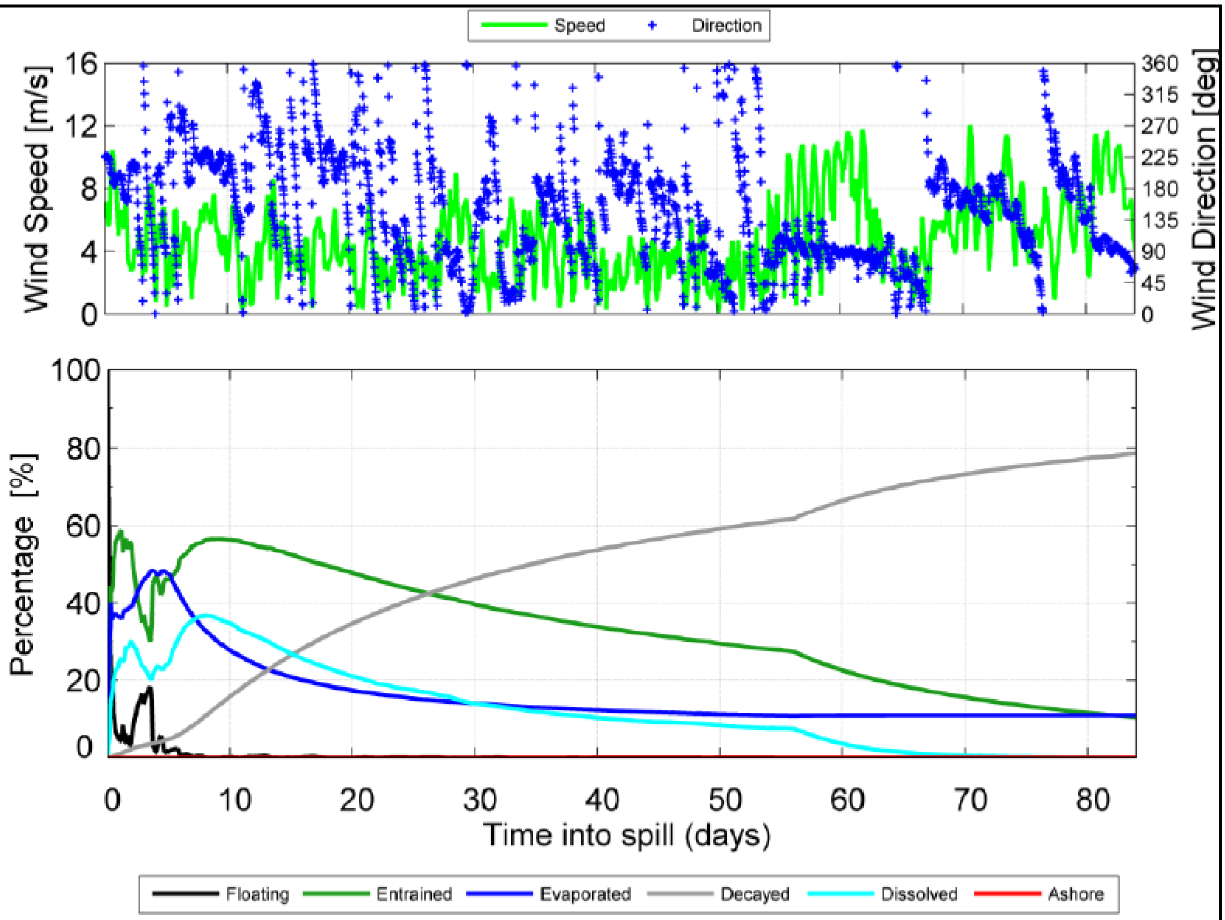

Figure 12-3: Gross mass balance plot representing the weathering of Egret-3 Medium Crude for a 56-day surface/subsurface release at Achernar-1.

Subsea Plume Dynamics

The well blowout surface/subsea release that has been modelled forecasts the size of the hydrocarbon droplets that would be released from the well as determined by the OILMAP-Deep model. **Table 12-7** shows a summary of the results of the OILMAP Deep modelling for the well blowout.

Table 12-7: Range of assumed inputs and range of calculated outputs, by OILMAP-Deep model for the surface/subsea well loss of containment (crude)

	Variable	Egret-3 condensate
Assumed discharge	Release Depth (m)	Surface (initial) 122 m (seabed release phase)
	Hydrocarbon temp (C°)	101°C
	Gas: Oil ratio (scf/bbl)	~1090
	Hydrocarbon flow rate (bbl/day)	234,812–292,762
	Diameter of exit hole (m)	0.311 m
Calculated gas plume dynamics	Plume diameter (m)	~7.9 m
	Plume Trapping height (m ASB)	122

Calculated droplet size distribution	droplets of size 7 µm droplets of size 15 µm droplets of size 22 µm droplets of size 30 µm droplets of size 37 µm	21.4 % 31.1 % 24.7 % 15.1 % 7.7 %

The results of the OILMAP simulation predict that the discharge will generate a cone of rising gas that will entrain the oil droplets and ambient sea water up to the water surface. The mixed plume is initially forecast to jet towards the water surface with a vertical velocity of around 9 m/s, gradually slowing and increasing in plume diameter as more ambient water is entrained. The diameter of the central cone of rising water and oil at the point of surfacing is predicted to be approximately 8 m.

The high discharge velocity and turbulence generated by the expanding gas plume is predicted to generate very small oil droplets (<50 µm) that will have very low-rise velocities (<0.015 cm/s). These droplets will be subject to mixing due to turbulence generated by the lateral displacement of the rising plume, as well as vertical mixing induced by wind and breaking waves. Therefore, despite reaching the surface due to the lift produced by the rising plume, the droplets will then tend to remain within the wave-mixed layer of the water column (3-10 m deep) where they can resist surfacing due to their weak buoyancy relative to other mixing processes.

Sensitivity Analysis – Discharge Velocity

Given the nature and scale of activity proposed Woodside commissioned sensitivity analysis on the exit velocity and the implications this has to the droplet size and therefore modelled hydrocarbon fate. The exit velocities calculated for the subsea phase of Scenarios 1A was 159.3 m/s. In our sensitivity analysis Woodside assumed an exit velocity of 80 m/s, which is half the predicted flow rate, to inform the sensitivity of the exit velocity on the modelled droplet size for the Petroleum Activities Program.

Recent literature suggests that droplet size distribution is directly related to the exit velocity from the release orifice (French-McCay *et al*. 2018). French-Mcay indicated that surfacing oil mass is approximately proportional to the flow rate and exit velocity. In addition, the percentage of spilled oil surfacing is inversely related to the rise time to the surface. French-McCay identifies from shallow water releases (<200 m), droplets <100 µm (d50 – median droplet size) could be considered permanently dispersed in the water column. Reduction in oil droplet size from a subsea blowout would disperse more oil into the water column, decreasing rise velocity of hydrocarbons, reducing floating hydrocarbons and resultant volumes ashore.

Modelling for the Petroleum Activity Program demonstrates the calculated droplet size has a maximum stable droplet size of 42 µm (Dmax) driven by the high flow rate and diameter of the exit hole, presented in **Table 12-8**, this resulted in a low rise velocity of approximately 0.02 cm/s. Results of the sensitivity analysis at the half flow rate increased the Dmax from 42 µm to 78 µm. The rise velocity calculated for a Dmax of 78 µm is approximately 0.0614 cm/s.

The large change in flow rate (50% reduction) used to inform the sensitivity analysis resulted in a minor distribution change to increasing droplet sizes and the rise velocity remained slow. French McCay et al 2018, indicates for a comparable depth and analogue profile, droplets < 100 µm could be considered permanently dispersed in the water column. Considering this, the overall distribution remains the same at the half flow rate and the majority of the released oil is likely to be subsea (pers Comm RPS APASA, 2019), hence the 50% reduction in flow rate and exit velocity will have no significant difference in modelled hydrocarbon results used to inform the risk assessment and oil spill response requirements

Quantitative Spill Risk Assessment – Loss of Well Control Condensate Scenario

Hydrocarbon Characteristics

Two condensates were selected for modelling, a GDA 01/02 composite condensate (for surface release) and a GDA 01 condensate (for subsea release). GDA 01/02 composite was modelled for the surface spill as it better reflects the expected change in hydrocarbon properties due to pressure differences exerted upon the hydrocarbon at the sea floor and sea surface.

Both GDA 01/02 Composite Condensate (API 51.6) and GDA 01 Condensate (API 58.6) contain relatively low proportions (~2.4% and ~1.6% by mass, respectively) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. Characteristics of both hydrocarbon analogues are provided in **Table 12-8**. The pour point of both analogues (-36 °C) ensures that they will remain in a liquid state over the annual temperature range observed on the North West Shelf. Additionally, both analogues have low asphaltene content (<1%), indicating a low propensity for the mixtures to take up water to form water-in-oil emulsion over the weathering cycle.

Table 12-8: GDA 01/02 Composite Condensate and GDA 01 Condensate characteristics

Oil Type	Density (g/cm^3)	Viscosity (cP) [at 21°C]	Component	Volatile (%)	Semi-Volatile (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			Boiling point (°C)	<180 C4 to C10	180–265 C11 to C15	265–380 C16 to C20	>380 >C20	Of whole oil <380 BP
GDA 01/02 Composite Condensate (surface release)	0.7723	0.857 at 20°C	% of total	61.3	23.6	12.7	2.4	15.9
			% aromatics	8.7	4.2	3.0	-	-
GDA 01 Condensate (subsea release)	0.7449	1.199 at 15°C	% of total	71.6	19.8	7.0	1.6	15.9
			% aromatics	8.7	4.2	3.0	-	-

The results for the weathering of the condensates indicate that the wind conditions will have a large impact on the proportion of oil that remains afloat, with very little oil mass predicted to persist on the sea surface (<1% after seven days). For both condensate analogues, the evaporation rate observed in the first 24 hours is similar in both weathering tests; however, as the wind speed increases in the variable-wind case, increased entrainment slightly reduces the proportion of oil available for evaporation, resulting in around 85-93% of the spilled volume expected to evaporate after seven days as compared to 88–94% for the constant-wind case.

For both condensate analogues, biological and photochemical degradation is predicted to contribute to the decay of the floating slicks at a similar rate for both weathering cases, with an approximate rate of <1% per day, and an accumulated total of about 1–2% after seven days.

A relatively small proportion of the spilled mass of GDA 01/02 composite and GDA 01 condensates will be expected to remain floating on the water surface, particularly under calm conditions, with a larger proportion predicted to entrain during higher ambient wind conditions.

For simplicity, the GDA 01/02 composite and GDA 01 condensates will be referred to combined as 'condensate' from hereon in.

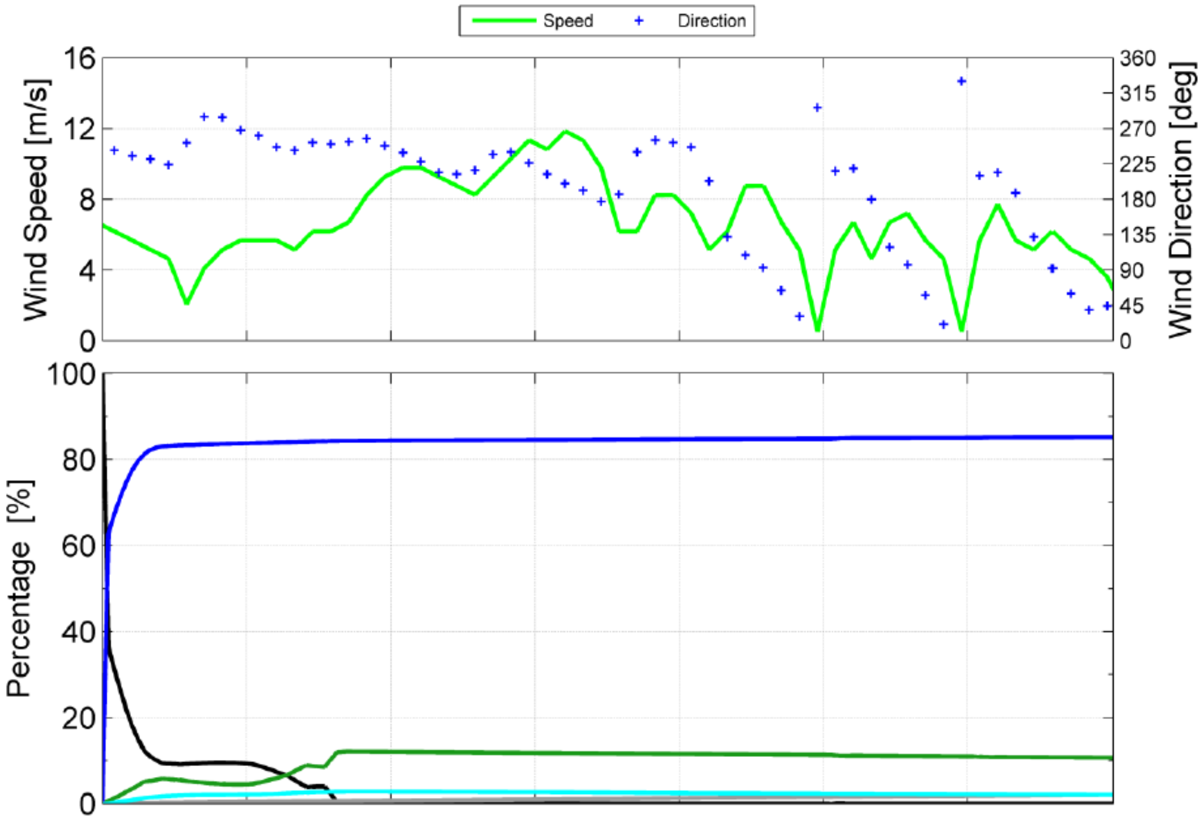

Figure 12-4: Proportional mass balance plot representing the weathering of 50 m³ from a surface spill of GDA 01/02 composite condensate

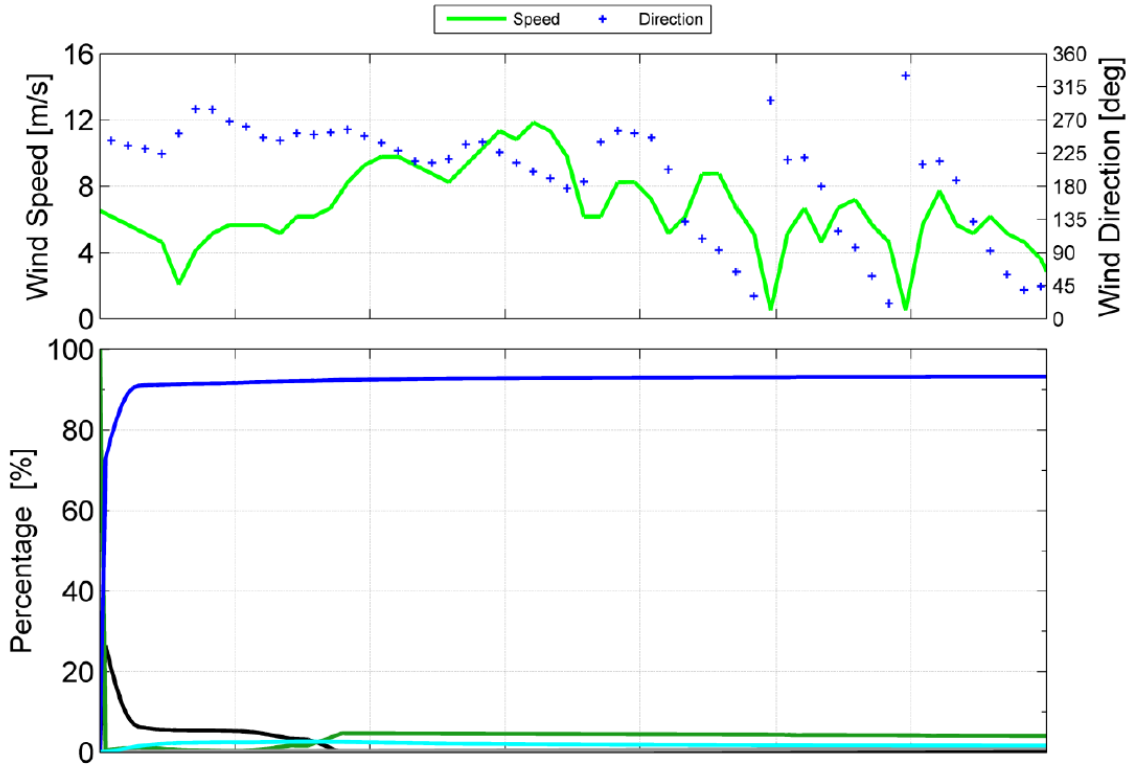

Figure 12-5: Proportional mass balance plot representing the weathering of 50 m³ from a surface spill of GDA 01 condensate

Subsea Plume Dynamics

The results of the OILMAP simulation predict that the discharge will generate a cone of rising gas that will entrain the oil droplets and ambient sea water up to the water surface. The mixed plume is initially forecast to jet towards the water surface with a vertical velocity of around 16 m/s, gradually slowing and increasing in plume diameter as more ambient water is entrained. The diameter of the central cone of rising water and oil at the point of surfacing is predicted to be approximately 8 m.

The high discharge velocity and turbulence generated by the expanding gas plume is predicted to generate very small oil droplets (<5 µm). These droplets will be subject to mixing due to turbulence generated by the lateral displacement of the rising plume, as well as vertical mixing induced by wind and breaking waves. The droplets will then tend to remain within the wave-mixed layer of the water column (3–10 m below sea surface), where they can resist surfacing due to their weak buoyancy relative to other mixing processes.

The results suggest that beyond the immediate vicinity of the blowout the majority of the released hydrocarbons will be present in the upper layers of the ocean, with the potential for oil to form floating slicks under sufficiently calm local wind conditions.

Table 12-9 shows a summary of the results of the OILMAP Deep modelling for the well blowout.

Table 12-9: Range of assumed inputs and range of calculated outputs, by OILMAP-Deep model for the surface/subsea well loss of containment (GDA 01 condensate)

	Variable	GDA 01 condensate
Assumed discharge	Release Depth (m)	Surface (initial) 122 m (seabed release phase)
	Hydrocarbon temp (C°)	102°C
	Gas:Oil ratio (scf/bbl)	~20,000
	Hydrocarbon flow rate (bbl/day)	43,161 – 44,846
	Diameter of exit hole (m)	0.216 m
Calculated gas plume dynamics	Plume diameter (m)	~7.9 m
	Plume Trapping height (m ASB)	122
Calculated droplet size distribution	droplets of size 1 µm	21.4 %
	droplets of size 2 µm	31.1 %
	droplets of size 3 µm	24.7 %
	droplets of size 4 µm	15.1 %
	droplets of size 5 µm	7.7 %

Impact Assessment

Potential Impacts Overview

Zone of Consequence – Crude

Surface Hydrocarbons

The ZoC depicted in these figures are a summary of all the locations where environmental thresholds could be exceeded for modelled scenarios.

Floating oil concentrations equal to or greater than the 10 g/m^2 threshold was predicted to occur within the model domain at the Montebello Islands (AMP and State MP), albeit at very low probabilities (<2%), minimum time to Montebello Island are 109 Hours.

Entrained Hydrocarbons

Modelling results indicated a number of environmental sensitivities may be contacted by entrained hydrocarbons above impact thresholds with time to contact ranging from 58 hours (Montebello AMP) to 1458 hours (Seringapatam Reef). In the event of a worst-case loss of well containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up to 1160 km from the release site. The most likely direction of drift is south-westerly around the Ningaloo Coast and then southwards, reflecting the prevailing current patterns. Results also indicate that entrained oil may also be likely to drift towards the northeast and in the offshore directions at lower probabilities. Cross-sectional transects of maximum entrained oil concentrations in the vicinity of the release site show that concentrations above 25,000 ppb are expected to extend from the sea surface to depths of around 30 m.

Dissolved Hydrocarbons

In the event of a loss of well containment scenario occurring, dissolved hydrocarbons at or above 500 ppb (environmental impact threshold) are forecast to potentially occur up to 690 km from the release site.

Accumulated Hydrocarbons

Potential for accumulation of oil on shorelines is predicted to be low. The highest probability of shoreline accumulation is at Montebello Islands, with maximum accumulated volume 140 m^3 (worst case replication). Maximum local accumulated concentration at the Montebello Marine park is predicted to be 6,007 g/m^2. Other shorelines with potential accumulation include Barrow Island, Bernier and Dorre Islands, Muiron Islands, Ningaloo Coast, Pilbara Islands, Rowley Shoals and Shark Bay (open coast and WHA) (**Table 12-10**).

Table 12-10: Accumulated shoreline concentration (crude)

Receptor Location	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Barrow Island	4,053	162
Berne and Dorre Islands	100	5
Dampier Archipelago	283	5
Montebello Islands	6,007	140
Muiron Islands MMA- WHA	1,328	37
Ningaloo Coast North WHA and coast	936	92
Ningaloo Coast Middle WHA and coast	1,646	163
Ningaloo Coast South WHA and coast	124	6
Pilbara Islands – Southern Island Group	5,656	180
Pilbara Islands – Middle Pilbara	320	8
Pilbara Islands – Northern Pilbara	130	2
Rowley Shoals – Clerke Reef MP	470	9
Rowley Shoals – Imperieuse Reef MP	714	8
Shark Bay Open Coast	376	37
Abrolhos Islands	77	4

Zone of Consequence – Condensate

Surface Hydrocarbons

During the initial surface release phase, the volatile fractions of the oil (~91.4%) are likely to evaporate within 24 hours of exposure to the atmosphere. The low-volatility fraction of the condensate (~7%) will take longer times of the order of days to weeks to evaporate, and the remaining fraction of ~1.6% is expected to persist for an extended period of time as residual oil.

During the subsurface release phase, the small oil droplets rapidly transported to the sea surface by the rising gas plume will be susceptible to re-entrainment into the wave-mixed layer under typical wind conditions. It is likely that the bulk of the oil mass will remain entrained in the water column until degradation processes occur. Due to the weak buoyancy of the oil droplets, the formation of floating slicks is unlikely, and therefore only a small fraction of the volatile compounds is likely to be exposed to the atmosphere. With low levels of evaporation expected, there is a high potential for dissolution of soluble aromatic compounds.

The probability contour figures for floating oil indicate that concentrations equal to or greater than the 1 g/m^2 and 10 g/m^2 thresholds could potentially be found, in the form of slicks, up to 185 km and 50 km from the spill site, respectively.

Montebello Islands are forecast to receive floating oil at concentrations equal to or greater than 1 g/m^2, with a probability of 2%. Lower probabilities (1%) of floating oil contact at this threshold are also forecast for other shoreline receptors.

Entrained Hydrocarbons

Entrained oil at concentrations equal to or greater than the 500 ppb threshold is predicted to be found up to around 360 km from the spill site.

Contact by entrained oil at concentrations equal to or greater than 500 ppb is predicted at Montebello AMP (38%) and Rankin Bank (24%), as well as at several other receptors with probabilities lower than 15%. The maximum entrained oil concentration forecast for any receptor is predicted as 4.7 ppm at Montebello AMP.

Dissolved Hydrocarbons

Dissolved aromatic hydrocarbons at concentrations equal to or greater than the 500 ppb threshold are predicted to be found up to 485 km from the spill site. Contact by dissolved aromatic hydrocarbons at concentrations equal to or greater than 500 ppb is predicted at Rankin Bank (35%) and Montebello AMP (30%), as well as at several other receptors with probabilities of less than -8%.

Accumulated Hydrocarbons

Potential for accumulation of oil on shorelines is predicted to be low. The highest probability of shoreline accumulation is at Barrow Island, with maximum accumulated volume 12 m^3 (worst case replication). Other shorelines with potential accumulation include Montebello Islands, Muiron Islands, Ningaloo Coast and Pilbara Islands (**Table 12-11**).

Table 12-11: Accumulated shoreline concentration (condensate)

Receptor Location	Maximum local accumulated concentration (g/m^2) in the worst replicate spill	Maximum accumulated volume (m^3) along this shoreline, in the worst replicate simulation
Montebello Islands	150	4
Barrow Island	223	12
Dampier Archipelago	84	2
Montebello Islands	150	4
Muiron Islands MMA- WHA	168	7
Ningaloo Coast North WHA and coast	68	10
Ningaloo Coast Middle WHA and coast	121	6
Ningaloo Coast South WHA and coast	-122	<1
Pilbara Islands – Southern Island Group	378	10
Shark Bay WHA	16	5

Summary of Potential Impacts

Table 12-11 presents the full extent of the ZoC, i.e. the sensitive receptors and their locations that may be exposed to either crude or condensate (surface, entrained, dissolved and accumulated) at or above the set threshold concentrations in the unlikely event of a major hydrocarbon release from a loss of well integrity during the Petroleum Activities Program. The potential biological and ecological impacts of an unplanned crude or condensate release as a result of a loss of well integrity during the Petroleum Activities Program are presented in the following sections.

Table 12-12: Zone of Consequence – Key Receptor Locations and Sensitivities with the Summary Hydrocarbon Spill Contact for a 56 day subsea blowout of crude and condensate

Environmental setting	Location/name	Crude ZoC	Condensate ZoC	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon contact and fate (Condensate)			
				Physical		Biological																						Socio-economic and Cultural								
				Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species									Other Species										
				Open water – (pristine)	Marine Sediment - (pristine)	Coral reef	Seagrass beds/Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non biogenic coral reefs	Offshore filter feeders and/or Deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Seasnakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas/Heritage – European and Indigenous/Shipwrecks	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
Offshore[5]	Commonwealth waters	✓	✓	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓	X	X	X	
	Agro-Rowley Terrace AMP	✓		✓						✓							✓	✓			✓			✓	✓	✓		✓			✓			X		
	Montebello AMP	✓	✓	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓*		X	X	X	
	Ningaloo AMP	✓		✓						✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓			X		
	Gascoyne AMP	✓	✓	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X	X	
	Shark Bay Open Ocean (including MP and WHA)	✓		✓	✓		✓			✓							✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					X
	Kimberley AMP	✓		✓	✓	✓	✓		✓	✓		✓					✓	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓			X		
	Imperieuse Reef (Rowley Shoals Marine Park)	✓		✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓			X	X	X
	Seringapatam Reef	✓		✓	✓	✓	✓		✓	✓		✓		✓				✓			✓	✓		✓	✓	✓	✓		✓	✓	✓			X		

[5] Note: hydrocarbons cannot accumulate on open ocean, submerged receptors, or receptors not fully emergent

Submerged Shoals	Rankin Bank	✓	✓	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓				X	X	
	Glomar Shoals	✓	✓	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓				X	X	
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X	X	X
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X	X	X
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓			X	X	X
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X	X	X
	Pilbara Islands – Northern Island Group	✓	✓	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X	X	X
	Dampier Archipelago	✓		✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			X		X
	Bernier & Dorre Islands	✓		✓	✓	✓	✓		✓	✓			✓	✓		✓		✓			✓	✓		✓	✓	✓	✓	✓		✓	✓			X		
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X	X	X
	Exmouth Gulf West	✓		✓	✓		✓	✓	✓	✓				✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓				X		

Summary of potential impacts to environmental values(s)	
The following summary of potential impacts considers the impacts of surface, entrained and dissolved hydrocarbon phases of both crude and condensate oil types on receptors identified in **Table 12-12**. Crude is much more persistent in the environment compared to condensate and is more amenable to the formation of surface slicks. Condensate, being a lighter hydrocarbon, entrains more readily in the water column and can spread for quickly, but at lower concentrations on the sea surface compared to crude. As such, any impacts arising from surface hydrocarbons identified below will be more relevant to a crude scenario compared to condensate, and impacts from entrained hydrocarbons more relevant to condensate compared to crude.	
Summary of potential impacts to protected species	
Setting	**Receptor Group**
Offshore, Oceanic Reefs and Islands	**Cetaceans** Marine mammals that have direct physical contact with surface, entrained or dissolved aromatic hydrocarbons may suffer surface fouling or ingestion of hydrocarbons and inhalation of toxic vapours. This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system or neurological damage (Helm *et al*., 2015). If prey (fish and plankton) are contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs). In a review of cetacean observations in relation to a number of large scale hydrocarbon spills, Geraci (1988) found little evidence of mortality associated with hydrocarbon spills, however, behavioural disturbance (i.e. avoiding spilled hydrocarbons) was observed in some instances for several species of cetacean. This suggests that cetaceans have the ability to detect and avoid surface slicks. A range of cetaceans were identified as potentially occurring within the PAA and wider ZoC. In the event of a loss of well containment, surface, entrained and dissolved hydrocarbons exceeding environmental impact threshold concentrations may drift across habitat for oceanic cetacean species and the migratory routes and BIAs of cetaceans considered to be MNES, including humpback whales and pygmy blue whales (north- and southbound migrations). Cetaceans that have direct physical contact with surface, entrained or dissolved aromatic hydrocarbons may suffer surface fouling, ingestion of hydrocarbons (from prey, water and sediments), aspiration of oily water or droplets and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system, neurological damage (Helm *et al*., 2015), reproductive failure, adverse health effects (e.g. lung disease, poor body condition) and potentially mortality (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). In a review of cetacean observations in relation to large scale hydrocarbon spills, it was concluded that exposure to oil from the Deepwater Horizon resulted in increased mortality to cetaceans in the Gulf of Mexico (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016), and long-term population level impacts to killer whales have been linked to the Exxon Valdez tanker spill (Matkin *et al*., 2008). Geraci (1988) has identified behavioural disturbance (i.e. avoiding spilled hydrocarbons) in some instances for several species of cetacean suggesting that cetaceans have the ability to detect and avoid surface slicks. However, observations during spills have recorded larger whales (both mysticetes and odontocetes) and smaller delphinids traveling through and feeding in oil slicks. During the Deepwater Horizon spill cetaceans were routinely seen swimming in surface slicks offshore (and nearshore) (Aichinger Dias *et al*., 2017). Cetacean populations that are resident within the ZoC may be susceptible to impacts from spilled hydrocarbons if they interact with an area affected by a spill. Such species are more likely to occupy coastal waters (refer to the mainland and islands section below for additional information). Suitable habitat for oceanic toothed whales (e.g. sperm whales) and dolphins (e.g. spinner dolphin) is broadly distributed throughout the region and as such, impacts are unlikely to affect an entire population. Other species identified may also have possible transient interactions with the ZoC. Physical contact with hydrocarbons to these species is

	likely to have biological consequences however it is unlikely to affect an entire population and not predicted to impact on the overall population viability. Given the nature of the hydrocarbon, it is expected to weather rapidly and remain entrained in the water column; cetaceans that may interact with spilled hydrocarbons are most likely to be subject to physical impacts. Given cetaceans maintain thick skin and blubber, external exposure to hydrocarbons may result in irritation to skin and eyes. Entrained hydrocarbons may also be ingested, particularly by baleen whales which feed by filtering large volumes of water. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) may have a higher potential to cause toxic effects when ingested, while weathered hydrocarbons are considered to be less likely to result in toxic effects. Pygmy blue whales and humpback whales are known to migrate seasonally through the wider ZoC, although the migration BIAs in the region for both species do not overlap the PAA. A major spill in July to December would coincide with humpback whale migration through the waters off the Pilbara, North West Cape and Shark Bay. A major spill in April to August or October to January would coincide with pygmy blue whale migration. Double *et al*. (2014) suggest that pygmy blue whales migrate in offshore waters west of the PAA in approximately 200–1000 m of water. Both pygmy blue and humpback whales are baleen whales, and hence, are most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is low level and opportunistic, with most feeding for both species in the Southern Ocean. As such, the risk of ingestion of hydrocarbons is low. Migrations of both pygmy blue whales and humpback whales are protracted through time and space (i.e. the whole population will not be within the ZoC), and as such, a spill from the loss of well containment is unlikely to affect an entire population. The humpback whale resting area in Exmouth Gulf and the calving area in Camden Sound are not predicted to be contacted by surface, entrained or dissolved hydrocarbons above threshold concentrations. A loss of well containment resulting in a well blowout could result in a disruption to a significant portion of the humpback or pygmy blue whale populations if the event occurred during the seasonal migration periods during which these species are present in the ZoC. Such disruption could include behavioural impacts (e.g. avoidance of impacted areas), sub-lethal biological effects (e.g. skin irritation, irritation from ingestion or inhalation, reproductive failure) and, in rare circumstances, death. However, such disruptions or impacts are not predicted to impact on the overall population viability.
	Marine Turtles Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon spills (National Oceanic and Atmospheric Administration, 2010). Contact with entrained (or floating) hydrocarbon can result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (National Oceanic and Atmospheric Administration, 2010). Given the modelling results indicated concentrations of floating hydrocarbons are not expected to exceed impact thresholds, the potential for contact with this hydrocarbon phase is very low. Oiling can also irritate and injure skin which is most evident on pliable areas such as the neck and flippers (Lutcavage *et al*., 1995). A stress response associated with this exposure pathway includes an increase in the production of white blood cells, and even a short exposure to hydrocarbons may affect the functioning of their salt gland (Lutcavage *et al*. 1995). Hydrocarbons in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the hydrocarbon spill (Milton and Lutz, 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (National Oceanic and Atmospheric Administration, 2010). Contact with entrained hydrocarbons can result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (Gagnon and Rawson, 2010). Given the hydrocarbon is expected to weather rapidly when released to the environment, relatively fresh entrained hydrocarbons (which are typically relatively close to the release location) are considered to have the

	greatest potential for impact. Due to the absence of potential nesting habitat and offshore location, the PAA is unlikely to represent important habitat for marine turtles. It is, however, acknowledged that marine turtles may be present foraging within the ZoC, and the ZoC would overlap with the BIAs, in particular, the internesting BIAs for flatback turtles which extend for ~80 km from known nesting locations. It is noted that the Petroleum Activities Program will coincide with nesting season for marine turtles in the region. In the event of a loss of well containment, there is potential that surface, entrained and dissolved hydrocarbons exceeding environmental impact threshold concentrations will be present in offshore waters. Therefore, a hydrocarbon spill may disrupt a portion of the population, but is unlikely to reduce overall population viability. Potential impacts to nesting and internesting marine turtles are discussed in the Mainland and Islands (nearshore) impacts discussion.
	Seasnakes Impacts to seasnakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation, 2011a). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. Given modelling indicated floating hydrocarbons are not expected to exceed impact thresholds, the potential for seasnakes to be exposed to floating hydrocarbons is considered to be very low. In general, seasnakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths <100 m; see Submerged Shoals below). It is acknowledged that seasnakes will be present in the PAA and wider ZoC; however, their abundance is not expected to be high in the deep water and offshore environment. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population but there is not considered to be a threat to overall population viability.
	Sharks and Rays Hydrocarbon contact may affect whale sharks through ingestion (entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks may transit offshore open waters when migrating to and from Ningaloo Reef, where they aggregate for feeding from March to July. A whale shark foraging BIA overlaps the PAA, and a foraging (high prey density) BIA lies approximately 338 km south-west of the PAA (off the Ningaloo Coast and within the wider ZoC). Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson, 2004). Therefore, individual whale sharks that have direct contact with hydrocarbons within the spill affected area may be impacted. Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs either through direct contact or via the food chain (consumption of prey). As gill breathing organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating of the gills inhibiting gas exchange). In the offshore environment, it is probable that pelagic shark species are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Therefore, any impact on sharks and rays is predicted to be minor and localised.
	Seabirds and Migratory Shorebirds Seabirds and migratory birds are particularly vulnerable to contact with floating hydrocarbons, which may mat feathers. This may lead to hypothermia from loss of insulation and ingestion of hydrocarbons when preening to remove hydrocarbons; both impacts may result in mortality (Hassan and Javed, 2011). The credible loss of well containment scenario results in highly localised floating hydrocarbons below impact thresholds centred around the release location; hence, the potential for seabird exposure to floating hydrocarbons is considered to be low. Migratory shorebirds are unlikely to interact with spilled hydrocarbons; refer to the sections on

	Islands and Mainland Coast below for a discussion on the potential impacts to migratory shorebirds. Offshore waters are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat, which includes the numerous islands along the Pilbara coast. There are a number of BIAs for seabirds and migratory shorebirds that overlap with the wider ZoC. Given the relatively low likelihood of encounters between seabirds and floating hydrocarbons, impacts to seabirds in offshore waters are expected to consist of ecosystem-scale effects, such as reduced prey abundance. Impacts from a loss of well containment to prey such as small pelagic fish (prey for the birds) are not expected to be significant; hence, subsequent impacts to a significant portion of seabirds are not expected. However, the extent of the ZoC for a surface slick as a result of a well blowout is predicted to be limited to approximately 290 km from the release. Therefore, a hydrocarbon spill is unlikely to result in the disruption of a significant portion of the foraging habitat for seabirds.
Submerged Shoals	**Marine Turtles** There is the potential for marine turtles to be present at submerged shoals such as Rankin Bank, Glomar Shoals and Rowley Shoals. These shoals and banks may, at times, be foraging habitat for marine turtles, given the coral and filter feeding biota associated with these areas. However, these areas are not known foraging locations. Tagging studies of green turtles did not indicate any overlap of the tracked post-nesting migratory routes and the PAA. It is, however, acknowledged that individual marine turtles may be present at Glomar Shoals, Rankin Bank, Rowley Shoals and the surrounding areas. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population (see offshore description above); however, there is no threat to overall population viability.
	Seasnakes There is the potential for seasnakes to be present at submerged shoals such as Rankin Bank, Glomar Shoals and Rowley Shoals. The potential impacts of exposure are as discussed previously in Offshore – Seasnakes. A hydrocarbon spill may have a minor disruption to a portion of the population but there is no threat to overall population viability.
	Sharks and Rays There is the potential for resident shark and ray populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. Spill model results indicate potential impacts to the benthic communities of Glomar Shoals and Rankin Bank, which may host shark and ray populations. Sharks and rays present at the submerged shoals may be exposed to fresh, unweathered hydrocarbons, which may have greater potential for toxic impacts. Any direct impacts are expected to be sub-lethal however no impacts at the population level. Pelagic sharks and rays are expected to move away from areas affected by spilled hydrocarbons. Impacts to such species are expected to be limited to behavioural responses/displacement. Shark and ray species that have associations with submerged shoals and oceanic atolls may not move in response to such habitat being contacted by spilled hydrocarbons. Such species may be more susceptible to a reduction in habitat quality resulting from a hydrocarbon spill. Impacts to sharks and rays at Rankin Bank and Glomar Shoals are likely to be localised as they are comparable to other Australian reefs and the NWMR submerged shoals and banks. It is expected that there will be no impacts at the population level.
Mainland and Islands (nearshore waters)	**All Species** The information provided on protected species in this section is in addition to that provided in the preceding Offshore and Oceanic Reefs and Submerged Banks and Shoals sections. Refer to these preceding sections for additional discussion of protected species.
	Cetaceans and Dugongs In addition to a number of whale species that may occur in nearshore waters (such as spotted bottlenose dolphins, Indo-Pacific humpback dolphins and snubfin dolphins), coastal

	populations of small cetaceans and dugongs are known to reside or frequent nearshore waters, including the Ningaloo Coast, Muiron Islands, Montebello/Barrow Islands, Pilbara Southern and Northern Island Groups, Shark Bay, and a number of other nearshore and coastal locations which may be potentially impacted by entrained and dissolved hydrocarbons exceeding threshold concentrations in the event of a loss of well containment. The loss of well containment scenarios ZoCs for entrained and dissolved hydrocarbons extends past Shark Bay. This area is a known humpback whale resting area during their annual southern migration and therefore, humpbacks moving into these aggregations areas may be exposed to hydrocarbons above thresholds levels. Shark Bay is also known as critical dugong habitat. Floating and entrained hydrocarbons reaching the Shark Bay region are not expected. The potential impacts of exposure are as discussed previously in Offshore – Cetaceans. However, nearshore populations of cetaceans and dugongs are known to exhibit site fidelity and are often resident populations. Therefore, avoidance behaviour may have greater impacts to population functioning. Nearshore dolphin species (e.g. spotted bottlenose dolphins) may exhibit higher site fidelity than oceanic species although Geraci (1988) observed relatively little impacts beyond behavioural disturbance. Additional potential environment impacts may also include the potential for dugongs to ingest hydrocarbons when feeding on oiled seagrass stands or indirect impacts to dugongs due to loss of this food source due to dieback in worse affected areas. Therefore, a hydrocarbon spill may have an impact on feeding habitats and result in a disruption to a significant portion of the local population but due to the non-persistent nature of the hydrocarbon it is not predicted to result in impacts on overall population viability of either dugongs or coastal cetaceans.
	Pinnipeds Australian sea lions are found in the Abrolhos Islands Nature Reserve distant from the PAA but within the wider ZoC. Given the considerable distance from the PAA to these receptors and the very low likelihood of surface and entrained hydrocarbons to contact (<1% probability of contact), surface or entrained hydrocarbons that do reach this area are likely to be heavily weathered and are expected to have minor or no impacts on sea lions.
	Marine Turtles Several marine turtle species utilise nearshore waters and shorelines for foraging and breeding (including internesting), with significant nesting beaches along the mainland coast and islands in potentially impacted locations such as the Ningaloo Coast, Muiron Islands, Montebello/Barrow Islands group, Dampier Archipelago, Pilbara Islands (Northern and Southern Island Groups) and Shark Bay. There are distinct breeding seasons. The nearshore waters of these turtle habitat areas may be exposed to entrained or dissolved hydrocarbons exceeding threshold concentrations, and accumulated hydrocarbons above threshold concentrations. The potential impacts of exposure are as discussed previously in Offshore – Marine Turtles. In the nearshore environment, turtles can ingest hydrocarbons when feeding or can be indirectly affected by loss of food source (e.g. seagrass due to dieback from hydrocarbon exposure) (Gagnon and Rawson, 2010). Given shoreline accumulation of hydrocarbons above impact thresholds was not predicted to occur, oiling of nesting females on shorelines is not considered credible. During the breeding season, turtle aggregations near nesting beaches within the wider ZoC are most vulnerable due to greater turtle densities and potential impacts may occur at the population level and may impact on overall population viability of some marine turtle species. However, given the volatile nature of the hydrocarbons and low levels of shoreline accumulation predicted, population level impacts will not occur.
	Sharks and Rays Whale sharks and manta rays are known to frequent the Ningaloo Reef system and the Muiron Islands (forming feeding aggregations in late summer/autumn). Whale sharks and manta rays generally transit along the nearshore coastline and are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large

	amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson, 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive sub-surface ram-feeding and active surface feeding (Taylor, 2007). Passive feeding consists of swimming slowly at the surface with the mouth wide open. During active feeding, sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor, 2007). These feeding methods would result in the potential for individuals that are present in worse affected spill areas to ingest potentially toxic amounts of entrained or dissolved aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect their endocrine and immune system in the longer term. The presence of hydrocarbons may cause displacement of whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks is planktonic organisms which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If the spill event were to occur during the spawning season, this important food supply (in worse spill affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by the whale shark may also result in long term impacts as a result of bioaccumulation. There is the potential for other resident shark and ray (e.g. sawfish species) populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. However, it is probable that shark species will move away from the affected areas, although sawfish may exhibit high habitat fidelity. **Table 12-12** indicates the receptor locations predicted to be impacted from entrained and/or dissolved aromatic hydrocarbons to the benthic communities of nearshore, subtidal communities, and it is considered that there is the potential for habitat loss to occur. Shark populations displaced or no longer supported due to habitat loss would be expected to redistribute to other locations. Therefore, the consequences to resident shark and ray populations (if present) from loss of habitat, may result in a disruption to a significant portion of the population, however, it is not expected to impact on the overall viability of the population.
	Seasnakes As discussed previously (see ‘Submerged shoals – seasnakes’) impacts to seasnakes for the mainland and island nearshore waters (including the Ningaloo Coast, Muiron Islands, Montebello/Barrow Islands, Dampier Archipelago, Southern Pilbara Island Groups and Shark Bay) from direct contact with hydrocarbons may occur but there is expected to be no threat to overall population viability.
	Seabirds and/or Migratory Shorebirds In the event of a loss of well containment, there is the potential for seabirds, and resident/non-breeding overwintering shorebirds that use the nearshore waters for foraging and resting, to be exposed to entrained and dissolved hydrocarbons. This could result in lethal or sub-lethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in nearshore waters near their breeding colony, resulting in intensive feeding by higher seabird densities in these areas during the breeding season and making these areas particularly sensitive in the event of a spill. Pathways of biological exposure that can result in impact may occur through ingestion of contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can also lead to internal injury to sensitive membranes and organs (International Petroleum Industry Environmental Conservation Association, 2004). Whether the toxicity of ingested hydrocarbons is lethal or sub-lethal will depend on the weathering stage and its inherent toxicity (note the shortest entrained hydrocarbon time to contact with a shoreline is 5.3 days (Barrow Island)). Exposure to hydrocarbons may have longer term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks, affecting survivorship and loss of adult birds.

	Migratory shorebirds may be exposed to stranded hydrocarbon when foraging or resting in intertidal habitats, however, direct oiling is typically restricted to relatively small portion of birds, and such oiling is typically restricted to the birds' feet. Modelling predicts that shoreline accumulation above impact thresholds would be very unlikely (Montebello Islands at 2% probability); the potential for impacts to migratory shorebirds by accumulated hydrocarbons on shorelines is considered to be very low. Suitable habitat or seabirds and shorebirds are broadly distributed along the mainland and nearshore island coasts within the ZoC. Of note are important nesting areas, including: • Muiron Islands • Ningaloo Coast • North West Cape • Montebello/Barrow/Lowendal Islands group (including known nesting habitats on Boodie, Double and Middle Islands) • Pilbara Islands North, Middle and South Island Group • Shark Bay • Dampier Archipelago. Therefore, a hydrocarbon spill may result in impacts on key feeding habitat and a disruption to a significant portion of the habitat; however, this is not expected to result in a threat to the overall population viability of seabirds or shorebirds.
Summary of potential impacts to other species	
Setting	**Receptor Group**
All Settings	**Pelagic and Demersal Fish** Fish mortalities are rarely observed to occur as a result of hydrocarbon spills (International Tanker Owners Pollution Federation, 2011b). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water, hence individuals exposed to a spill are likely to recover (King *et al*., 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) have occurred in sheltered bays. Laboratory studies have shown that adult fish are able to detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after oil spills (Hjermann *et al*., 2007). This suggests that juvenile and adult fish are capable of avoiding water contaminated with high concentrations of hydrocarbons. However, sub-lethal impacts to adult and juvenile fish may be possible, given long-term exposure (days to weeks) to PAH concentrations (Hjermann *et al*., 2007). While modelling of the loss of well containment indicates the potential ZoC for dissolved hydrocarbons is extensive, no time-integrated exposure metrics were modelled; given the oceanographic environment within the wider ZoC, PAH exposures in the order of weeks for pelagic fish are not considered credible. The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and to a lesser extent affects fish consuming contaminated food (Cohen *et al*., 2005). The liver, a major detoxification organ, appears to be the organ where anaerobic activity is most impacted, probably increasing anaerobic activity to facilitate the elimination of ingested oil from the fish (Cohen *et al*., 2005). Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck, 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and

	Heck, 2011). More subtle, chronic effects on the life history of fish as a result of exposure of early life stages to hydrocarbons include disruption to complex behaviour such as predator avoidance, reproductive and social behaviour (Hjermann *et al*., 2007). Prolonged exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann *et al*., 2007). PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen *et al*., 2017). However, the effect of a hydrocarbon spill on a population of fish in an area with fish larvae and/or eggs, and the extent to which any of the adverse impacts may occur, depends greatly on prevailing oceanographic and ecological conditions at the time of the spill and its contact with fish eggs or larvae. Demersal fish species are associated with the both the Glomar and Rowley Shoals and Ancient coastline at 125 m depth contour KEFs which overlap the PAA and provide habitat for demersal fish species. Rankin Bank (approximately 100 km from the PAA) also hosts a diverse demersal fish assemblage. In addition, the ZoC extends over the Continental Slope Demersal Fish Communities KEF. Fish associated with these features may be exposed to dissolved and entrained hydrocarbons above impact thresholds. Mortality and sub lethal effects may impact populations located close to the well blow out and within the ZoC for entrained/dissolved aromatic hydrocarbons (≥500 ppb). Additionally, if prey (infauna and epifauna) surrounding the well location and within the ZoC is contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs) potentially impacting fish populations that feed on these. These impacts may result in localised medium/long term impacts on demersal fish habitat, e.g. seafloor.
Summary of potential impacts to marine primary producers	
Setting	**Receptor Group**
Oceanic Reef and Offshore Islands	The waters overlying Glomar and Rowley Shoals as well as Rankin bank have the potential to be exposed to entrained and dissolved hydrocarbons above threshold concentrations (>500 ppb) within a relatively short space of time after a loss of well containment (5.3 days Glomar Shoals, 26.3 days Rowley Shoals, and 3.1 days Rankin Bank). This permanently submerged habitat represents sensitive oceanic reef benthic community receptors, extending from deep depths to relatively shallow water. Given the depth of Rankin Bank and Glomar Shoals, it is likely the potential for biological impact is reduced when compared to the upper water column layers. However, contact at or above entrained and dissolved thresholds is predicted based on modelling resulting in potential biological impacts including sub-lethal stress and in some instances total or partial mortality of sensitive benthic organisms such as corals and the early life stages of resident fish and invertebrate species. Other submerged shoals and banks within the wider ZoC (e.g. Rowley Shoals) are also predicted to be exposed to entrained or dissolved hydrocarbons above threshold concentrations, but with longer times to contact (and hence, greater potential for hydrocarbon weathering) and therefore impacts are expected to be less.
Submerged Shoals	**Open Water** Productivity/Upwelling: The submerged shoals of Rankin Bank, Rowley Shoals and Glomar Shoals are areas associated with sporadic upwelling and associated primary productivity events. Spill model results predict entrained hydrocarbons (at or above the 500 ppb threshold) may reach Rankin bank, Glomar Shoals and Rowley Shoals. Therefore, impacts to plankton communities may result in short-term changes in plankton community composition but recovery would occur (see offshore description above). Hydrocarbon contact during the spawning seasons for resident shoal community benthos and fish (meroplankton), particularly exposure to in-water toxicity effects to biota, may result in the loss of a discrete cohort population but would not affect the longer-term viability of resident populations. Therefore, any impacts to resident shoal community benthos and fish (meroplankton) are likely to be localised at the shoals and temporary.
	Filter Feeders

	Hydrocarbon exposure to offshore filter-feeding communities (e.g. communities around Rankin Bank in water depths between 80–100 m) may occur depending on the depth of the entrained/dissolved hydrocarbons. Exposure to entrained hydrocarbons/dissolved aromatic hydrocarbons (≥500 ppb) has potential to result in lethal or sub-lethal toxic effects. Sub-lethal impacts, including mucus production and polyp retraction, have been recorded for gorgonians exposed to hydrocarbon (White *et al*. 2012). Any impacts may result in localised long-term effects to community structure and habitat.
Mainland and Islands (nearshore waters)	**Coral Reef** The quantitative spill risk assessment and ZoC indicate there would be potential for coral reef habitat to be exposed to dissolved and entrained hydrocarbons. There would be potential for entrained and dissolved hydrocarbons above threshold concentrations to reach reef habitat along the Ningaloo Coast and at identified offshore islands and coastline (see **Table 12-12**) such as the Muiron Islands, Montebello/Barrow Islands, Dampier Archipelago, Pilbara Islands (North, Middle and Southern) and Shark Bay. The shallow coral habitats are most vulnerable to hydrocarbon coating by direct contact with surface slicks during periods when corals are tidally-exposed at spring low tides; such slicks are not expected to form in the event of a loss of well containment for the Petroleum Activities Program due to the nature of the hydrocarbon. Water soluble hydrocarbon fractions associated with surface slicks are also known to cause high coral mortality (Shigenaka, 2001) via direct physical contact of hydrocarbon droplets to sensitive coral species (such as the branching coral species). Note the dissolved ZoC for a loss of well containment may reach a number of coral receptors (**Table 12-12**). There is significant potential for lethal impacts due to the physical hydrocarbon coating of sessile benthos (e.g. by entrained hydrocarbons), with likely significant mortality of corals (adults, juveniles and established recruits) at the small spill affected areas. This particularly applies to branching corals which are reported to be more sensitive than massive corals (Shigenaka, 2001). Exposure to entrained hydrocarbons/dissolved aromatic hydrocarbons (≥500 ppb) has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals), reef flat (intertidal corals) and lagoonal (back reef) coral communities (with reference to Ningaloo Coast). Mortality in a number of coral species is possible and this would result in the reduction of coral cover and change in the composition of coral communities. Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward, 2000). This could result in impacts to the shallow water fringing coral communities/reefs of the offshore islands (e.g. Muiron Islands, Barrow/Montebello Islands, Dampier Archipelago, Pilbara Southern and Northern Island Groups) and also the mainland coast (e.g. Ningaloo Coast and Shark Bay). With reference to Ningaloo Reef, wave-induced water circulation flushes the lagoon and may promote removal of entrained and dissolved hydrocarbons from this particular reef habitat. Under typical conditions, breaking waves on the reef crest induce a rise in water level in the lagoon creating a pressure gradient that drives water in a strong outward flow through channels. In the unlikely event of a spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is the potential for a significant reduction in successful fertilisation and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward, 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained and dissolved aromatic hydrocarbons, resulting in sub-lethal impacts and in some cases mortality. This is with particular reference to the early life-stages of coral reef animals (reef attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site attached, have small home ranges and as reef residents they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities (which may include fringing reefs of the offshore islands and/or the Ningaloo reef system) will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. Over the worst affected sections of reef habitat, coral community live cover, structure and

	composition is predicted to reduce, manifested by loss of corals and associated sessile biota. Recovery of these impacted reef areas typically relies on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. For example, there is evidence that Ningaloo Reef corals and fish are partly self-seeding (Underwood, 2009) with the supply of larvae from locations within Ningaloo Reef of critical importance to the healthy maintenance of the coral communities. Recovery at other coral reef areas, may not be aided by a large supply of larvae from other reefs, with levels of recruits after a disturbance event only returning to previous levels after the numbers of reproductive corals had also recovered (Gilmour *et al*., 2013). Therefore, a hydrocarbon spill may result in large-scale impacts to coral reefs, particularly Ningaloo Reef, with long-term effects (recovery >10 years) likely.
	Seagrass Beds/Macroalgae and Mangroves Spill modelling has predicted entrained and dissolved hydrocarbons above threshold concentrations have the potential to contact a number of shoreline sensitive receptors such as those supporting biologically diverse, shallow subtidal and intertidal communities. The variety of habitat and community types, from the upper subtidal to the intertidal zones support a high diversity of marine life and are utilised as important foraging and nursery grounds by a range of invertebrate and vertebrate species. Depending on the trajectory of the entrained and dissolved hydrocarbon plume, macroalgal/seagrass communities including the Ningaloo Coast (patchy and low cover associated with the shallow limestone lagoonal platforms), Muiron Islands (associated with limestone pavements), the Barrow/Montebello Islands, Shark Bay, the Pilbara Island Groups and the Dampier Archipelago have the potential to be exposed (see **Table 12-12** for a full list of receptors within the ZoC). Seagrass in the subtidal and intertidal zones have different degrees of exposure to hydrocarbon spills. Subtidal seagrass is generally considered much less vulnerable to hydrocarbon spills than intertidal seagrass, primarily because freshly spilled hydrocarbons, including crude oil, float under most circumstances. Dean *et al*. (1998) found that oil mainly affects flowering, therefore, species that are able to spread through apical meristem growth are not as affected (such as *Zostera*, *Halodule* and *Halophila* species). Seagrass and macroalgal beds occurring in the intertidal and subtidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie *et al*., 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. Minimum time to contact with receptors that may host seagrasses are 3.3 days (Montebello State Marine Park) and 4.3-days (Barrow Island). As such, hydrocarbons released in the event of a loss of well containment are expected to be weathered prior to any credible contact with seagrasses. Exposure to entrained aromatic hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentration received and duration of exposure. Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, causing reduced growth rates and a reduction in tolerance to other stress factors (Zieman *et al*., 1984). Impacts on seagrass and macroalgal communities are likely to occur in areas where hydrocarbon threshold concentrations are exceeded. Mangroves and associated mud flats and salt marsh at Ningaloo Coast (small habitat areas) and the Montebello Islands and Barrow Island have the potential to be exposed to entrained hydrocarbons (see **Table 12-12** for the full list of receptors). Hydrocarbons coating prop roots of mangroves can occur from entrained hydrocarbons when hydrocarbons are deposited on the aerial roots. Hydrocarbons deposited on the aerial roots can block the pores used to breathe or interfere with the trees' salt balance resulting in sub-lethal and potential lethal effects. Mangroves can also be impacted by entrained/dissolved aromatic hydrocarbons that may adhere to the sediment particles. In low energy environments, such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (National Oceanic and Atmospheric Administration, 2014). Given the non-persistent nature of the hydrocarbons, no significant effects to mangroves are expected to occur. Entrained/dissolved hydrocarbon impacts may include sub-lethal stress and mortality to

	certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss of habitats and/or lethal and sub-lethal in-water toxic effects. This may result in mortality or impairment of growth, survival and reproduction (Heintz *et al*., 2000). In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that utilise these intertidal habitat areas for breeding, feeding and nursery habitat purposes.
Summary of potential impacts to other habitats and communities	
Setting	**Receptor Group**
Offshore	**Benthic Fauna Communities** In the event of a loss of well containment at the seabed, the stochastic spill model predicted hydrocarbons droplets would be entrained in a gas plume, transporting them to the water column and sea surface. As a result, the low sensitivity benthic communities associated with the unconsolidated, soft sediment habitat and any epifauna (filter feeders) within and outside the PAA are not expected to be exposed to released hydrocarbons. A localised area relating to the hydrocarbon plume at the point of release is predicted, which would result in a small area of seabed and associated epifauna and infauna exposed to hydrocarbons.
	Open Water – Productivity/Upwelling Primary production by plankton (supported by sporadic upwelling events in the offshore waters of the NWS) is an important component of the primary marine food web. Planktonic communities are generally mixed including phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton, such as crustaceans (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton). Exposure to hydrocarbons in the water column can result in changes in species composition with declines or increases in one or more species or taxonomic groups (Batten *et al*., 1998). Phytoplankton may also experience decreased rates of photosynthesis (Tomajka, 1985). For zooplankton, direct effects of contamination may include toxicity, suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation. Impacts on plankton communities are likely to occur in areas where entrained or dissolved aromatic hydrocarbon threshold concentrations are exceeded, but communities are expected to recover relatively quickly (within weeks or months). This is due to high population turnover with copious production within short generation times that also buffers the potential for long-term (i.e. years) population declines (International Tanker Owners Pollution Federation, 2011a). Therefore, impacts on exposed planktonic communities present in the ZoC are likely to be short-term.
Islands and Mainland (Nearshore Waters)	**Open Water – Productivity/Upwelling** Nearshore waters and adjacent offshore waters surrounding the offshore islands (e.g. Barrow and Montebello Islands) and to the west of the Ningaloo reef system are known locations of seasonal upwelling events and productivity. The seasonal productivity events are critical to krill production, which supports megafauna aggregations such as whale sharks and manta rays in the region. This has the potential to result in lethal and sub-lethal impacts to a certain portion of plankton in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. However, recovery would occur (see offshore description above). Therefore, any impacts are likely to be on exposed planktonic communities present in the ZoC and temporary in nature.
	Spawning/Nursery Areas Fish (and other commercially targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sub-lethal impacts from exposure to hydrocarbons, particularly if a spill coincides with spawning seasons or if a spill reaches nursery areas close to the shore (e.g. seagrass and mangroves) (International Tanker Owners Pollution Federation, 2011a). Fish spawning (including for commercially targeted species) occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a major spill there is potential for entrained

	hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters including, but not limited to the Montebello Islands, Barrow Island, Ningaloo Coast and Shark Bay. This, and the potential for possible lower concentration exposure for dissolved aromatic hydrocarbons, have the potential to result in lethal and sub-lethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Although there is the potential for spawning/nursery habitat to be impacted (e.g. mangroves and seagrass beds, discussed above), losses of fish larvae in worst affected areas are unlikely to be of major consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). This is consistent with a recent study in the Gulf of Mexico which used juvenile abundance data, from shallow-water seagrass meadows, as indices of the acute, population-level responses of young fishes to the Deepwater Horizon spill (Fodrie and Heck, 2011). Results indicated that there was no change to the juvenile cohorts following the Deepwater Horizon spill. Additionally, there were no significant post-spill shifts in community composition and structure, nor were there changes in biodiversity measures (Fodrie and Heck, 2011). Any impacts to spawning and nursery areas are expected to be minor and short term, as would flow on effects to adult fish stocks into which larvae are recruited.
	Reefs The reef communities fringing the offshore Ningaloo Coast region may be exposed to entrained hydrocarbons (>500 ppb) and consequently exhibit lethal or sub-lethal impacts resulting in partial or total mortality of keystone sessile benthos, particularly, hard corals and thus potential community structural changes to these shallow, nearshore benthic communities may occur. In the event that these reefs are exposed to entrained hydrocarbons, impacts are expected to result in localised long-term effects.
	Filter Feeders Hydrocarbon exposure to offshore, filter-feeding communities (e.g. deep water communities of Ningaloo coast in 20–200 m) may occur depending on the depth of the entrained and dissolved aromatic hydrocarbons. See discussion above on potential impacts.
	Sandy Shores/Estuaries/Tributaries/Creeks (Including Mudflats)/Rocky Shores Shoreline exposure for the upper and lower areas differ, the shore has the potential to be exposed to dissolved or entrained hydrocarbon. Potential impacts may occur due to hydrocarbon contact with intertidal areas, including sandy shores, mudflats and rocky shores, listed in **Table 12-12**. Hydrocarbon at sandy shores is incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores. Hydrocarbon in the intertidal zone can adhere to sand particles however high tide may remove some or most of the hydrocarbon back of the sediments. Typically, hydrocarbon is only incorporated into the surface layers to a maximum of 10 cm. As described earlier, accumulated hydrocarbons ≥ 100 g/m^2 could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat (French-McCay, 2009). Note that shoreline accumulation above impact thresholds was identified as potentially occurring at Barrow/Montebello/Lowendal Islands group. Given the hydrocarbons are non-persistent, long-term impacts to shores are not expected. The impact of hydrocarbon on rocky shores will be largely dependent on the incline and energy environment. On steep/vertical rock faces on wave exposed coasts there is likely to be no impact from a spill event. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of hydrocarbon (International Petroleum Industry Environmental Conservation Association, 2004). The impact of the spill on marine organisms along the rocky coast will be dependent on the toxicity and weathering of the hydrocarbon. Similar to sandy shores accumulated hydrocarbons ≥ 100 g/m^2 could coat the epifauna along rocky coasts and impact the reproductive capacity and survival. The locations of rocky shores where impacts are predicted are at Barrow/Montebello/Lowendal Islands group. Intertidal mudflats are susceptible to potential impacts from hydrocarbons as they are typically low energy environments and therefore trap hydrocarbons. The extent of oiling is influenced by the neap and spring tidal cycle and seasonal highs and lows affecting mean sea level.

	Potential impacts to tidal flats include heavy accumulations covering the flat at low tide however it is unlikely that hydrocarbon will penetrate the water-saturated sediments. However, hydrocarbon can penetrate sediments through animal burrows and root pores. It has been demonstrated that infaunal burrows allow hydrocarbons to subsurface sediments where it can be retained for months. Potential impacts may occur due to entrained contact with shallow, subtidal and intertidal zones of the Ningaloo Coast, and shoreline accumulation at Barrow Island, Montebello Islands and the Muiron Islands. In-water toxicity of the dissolved and entrained hydrocarbons reaching these shores will determine impacts to the marine biota such as sessile barnacle species and/or mobile gastropods and crustaceans such as amphipods. Lethal and sub-lethal impacts may be expected where the entrained hydrocarbon concentration threshold is >500 ppb. Impacts may result in localised changes to the community structure of these shoreline habitats which would be expected to recover in the medium term (2–5 years).
Key Ecological Features	**Key Ecological Features** Potentially impacted by the hydrocarbon spill from a loss of well containment event are the following KEFs: • Glomar Shoals • Ancient coastline at 125 m depth contour • Continental Slope Demersal Fish Communities • Exmouth Plateau • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula • Mermaid Reef and Commonwealth waters surrounding Rowley Shoals • Commonwealth waters adjacent to Ningaloo Reef • Western demersal slope and associated fish communities • Western rock lobster • Ancient coastline at 90-120 m depth • Commonwealth marine environment surrounding the Houtman Abrolhos Islands. Although these KEFs are primarily defined by seabed geomorphological features, they are described to identify the potential for increased biological productivity and, therefore, ecological significance. The consequences of a hydrocarbon spill from a loss of well containment may impact the values of the KEFs affected. Potential impacts include: the contamination of sediments, impacts to benthic fauna/habitats and associated impacts to demersal fish populations and reduced biodiversity as described above and below. Most of the KEFs within the ZoC have relatively broad-scale distributions and are unlikely to be significantly impacted.
Summary of potential impacts to water quality	
Setting	**Aspect**
Offshore	**Open Water – Water Quality** Water quality would be affected due to hydrocarbon contamination which is described in terms of the biological effect concentrations. These are defined by the ZoC descriptions for entrained and dissolved hydrocarbon fates and their predicted extent. Furthermore, water quality is predicted to have minor long term and/or significant short term hydrocarbon contamination above background and/or national/international quality standards.
Submerged Shoals	**Open Water – Water Quality** Water quality would be reduced due to hydrocarbon contamination that is predicted to be at or above biological effect concentrations for the surrounding marine waters over Rankin Bank. The submerged Rankin Bank and Glomar and Rowley shoals has the potential to be exposed to entrained hydrocarbons at or greater than 500 ppb. The waters surrounding this permanently submerged habitat, would show a reduction in quality due to hydrocarbon contamination above background and/or national/international quality standards.

Mainland and Islands (Nearshore waters)	**Open Water – Water Quality** Water quality would be affected/reduced due to hydrocarbon contamination, with modelling predictions indicating that hydrocarbon contact is at or above biological effect concentrations for entrained hydrocarbons in nearshore waters of identified islands and the mainland coast (refer to **Table 12-12**). Such reduction in water quality is predicted to have minor long term or significant short term hydrocarbon contamination above background and/or national/international quality standards.
Summary of potential impacts to marine sediment quality	
Setting	**Receptor Group**
Offshore	**Marine Sediment Quality** In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of condensate would atomise into droplets that would be rapidly transported into the water column to the surface. As a result the extent of potential impacts to the seabed area at and surrounding the release site would be confined to a localised footprint. Marine sediment quality would be reduced (contamination above national/international quality standards) as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term.
Submerged Shoals	**Marine Sediment Quality** There is potential for the reduction of marine sediment quality due to contact and adherence of entrained hydrocarbons with seabed sediments of the submerged shoals. If this was to occur, marine sediment quality would be reduced (contamination above national/international quality standards) as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term. However, given the nature of the hydrocarbon, contact with submerged shoals is considered unlikely.
Mainland and Islands (Nearshore waters)	**Marine Sediment Quality** Entrained hydrocarbons (at or above the defined thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines and hydrocarbons may accumulate (at or above the ecological threshold) at the Montebello Islands (refer to **Table 12-12**). Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat.
Summary of potential impacts to air quality	
A hydrocarbon release during a loss of well containment event has the potential to result in localised, temporary reduction in air quality. Potential impacts are expected to be a slight and temporary localised effect to ecosystems, species and/or habitats in the area. There is potential for human health effects for workers in the immediate vicinity of atmospheric emissions. The ambient concentrations of methane and volatile organic carbons (VOCs) released from diffuse sources is difficult to accurately quantify, although their behaviour and fate is predictable in open offshore environments as it is dispersed rapidly by meteorological factors such as wind and temperature. Methane and VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photo chemically-produced hydroxyl radicals. Due to the unlikely occurrence of a loss of well containment; the temporary nature of any methane or VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment); the predicted behaviour and fate of methane and VOCs in open offshore environments; and the significant distance from the Permit Area to the nearest sensitive air shed (town of Dampier approximately 140 km away), the potential impacts are expected to be minor and temporary.	
Summary of potential impacts to protected areas	
The quantitative spill risk assessment results indicate that the open water environment protected within the Commonwealth marine parks listed in refer to **Table 12-12** may be affected by the released hydrocarbons. In the unlikely event of a major spill and entrained hydrocarbons and/or dissolved hydrocarbons may contact	

the identified key receptor locations of islands and mainland coastlines resulting in the actual or perceived contamination of protected areas as identified for the ZoC (refer to **Table 12-12**).

Objectives in the Ningaloo Marine Park (Commonwealth Waters) Management Plan, Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area and Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves require considerations to a number of physical, ecological and social values identified in these areas. Impact on the values of this protected area is discussed in the relevant sections above for ecological and physical (water quality) values and below for social (socio-economic) values.

Impact on the protected areas is discussed in the sections above for ecological the values and sensitivities and below for socio-economic values. Additionally, such hydrocarbon contact may alter stakeholder understanding and/or perception of the protected marine environment, given these represent areas largely unaffected by anthropogenic influences and contain biological diverse environments.

Summary of potential impacts to socio-economic values

Setting	Receptor Group
Offshore	**Fisheries – Commercial** Spill scenarios modelled are unlikely to cause significant direct impacts on the target species of Commonwealth and offshore State fisheries within the defined ZoC. Further details are provided below (impact assessment relating to spawning is discussed above under ‘Summary of potential impacts to other habitats and communities’). 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. Tainting is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it is dependent upon the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender *et al*., 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing, and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender *et al*., 2002). A major spill would result in the establishment of a Petroleum Safety Zone around the spill affected area. There would be a temporary prohibition on fishing activities for a period of time and subsequent potential for economic impacts to affected commercial fishing operators. Additionally, hydrocarbon can foul fishing equipment such as traps and trawl nets, requiring cleaning or replacement.
	Tourism including Recreational Activities Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with the peak in activity between April and October (Smallwood *et al*., 2011). Limited recreational fishing takes place in the offshore waters of the PAA due to the distance from shore; however, fishing may take place at Rankin Bank and Glomar Shoals. Impacts on species that are recreationally fished are described above and under ‘Summary of potential impacts to other species’ above. A major loss of hydrocarbon from the Petroleum Activities Program may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for operators.
	Offshore Oil and Gas Infrastructure In the unlikely event of a major spill, surface hydrocarbons may affect production from existing petroleum facilities (platforms and FPSOs). For example, facility water intakes for cooling and fire hydrants could be shut off which could in turn lead to the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit activity support vessel access as well as tankers approaching facilities on the NWS. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and metocean conditions. Furthermore, decisions on the operation of production facilities in the event of a spill would be based primarily on health and safety considerations. The closest oil and gas operation is the Okha FPSO, 10 km from the PAA. Other nearby facilities includes the North Rankin Complex (25 km) Angel Platform

	(35 km) which also has an export pipeline traversing the PPA. All are operated by Woodside. Operation of these facilities is likely to be affected in the event of a worst-case loss of well containment.
Submerged shoals	**Tourism and Recreation** In the unlikely event of a major spill, a temporary prohibition on charter boat recreational fishing trips and any other marine nature-based tourism trips to Rankin Bank and Rowley Shoals may be put into effect, depending on the trajectory of the plume, resulting in a loss of revenue for operators.
Mainland and Islands (Nearshore Waters)	**Fisheries – Commercial** Nearshore Fisheries and Aquaculture: In the unlikely event of a loss of well containment, there is the possibility that target species in some areas utilised by a number of state fisheries in nearshore waters of the Ningaloo Coast and Shark Bay, and aquarium fisheries and aquaculture activities in the nearshore waters that are within the ZoC could be affected. Targeted fish resources could experience sub-lethal stress, or in some instances, mortality depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. *Prawn Managed Fisheries* In the event of a major spill, the modelling indicated the surface, entrained and dissolved ZoC may extend to nearshore waters closest to the mainland Pilbara and Gascoyne coasts, including the actively fished areas of the designated Onslow Prawn Managed Fishery, Exmouth Gulf Prawn managed Fishery and the Shark Bay Prawn and Scallop Managed Fishery, and managed prawn nursery areas. Note that the majority of the demarcated area for the prawn managed fishery in the Exmouth Gulf (proper) is outside the ZoC. Prawn habitat utilisation differs between species in the post-larval, juvenile and adult stages (Dall *et al*., 1990) and direct impacts to benthic habitat due to a major spill has the potential to impact prawn stocks. For example, juvenile banana prawns are found almost exclusively in mangrove-lined creeks, whereas juvenile tiger prawns are most abundant in areas of seagrass (Masel and Smallwood, 2000). Adult prawns also inhabit coastline areas but tend to move to deeper waters to spawn. In the event of a major spill, the model predicted shallow subtidal and intertidal habitats at the Ningaloo Coast, and mangrove and seagrass habitats of the Ningaloo Coast are located within the ZoC and could be exposed to hydrocarbon concentrations above threshold concentrations, depending on the trajectory of the plume. Localised loss of juvenile prawns in worse spill affected areas is possible. Whether lethal or sub-lethal effects occur will depend on duration of exposure, hydrocarbon concentration and weathering stage of the hydrocarbon and its inherent toxicity. Furthermore, seafood consumption safety concerns and a temporary prohibition on fishing activities may lead to subsequent potential for economic impacts to affected commercial fishing operators.
	Fisheries – Traditional Although no designated traditional fisheries have been identified it is recognised that Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon spill from a loss of well containment were to occur. Impacts would be similar to those identified for commercial fishing in the form of a potential Petroleum Safety zone and contamination/tainting of fish stocks.
	Tourism and Recreation In the unlikely event of a major spill, the nearshore waters of the Ningaloo Coast could be reached by entrained hydrocarbon, depending on prevailing wind and current conditions. This location offers a number of amenities such as fishing, swimming and utilisation of beaches and surrounds, which have a recreational value for local residents and visitors (regional, national and international). If a major spill resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering or tides and currents remove the hydrocarbons. In the event of a major spill, tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed. There is potential for stakeholder perception that this remote environment will be

	contaminated over a large area and for the longer term resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill related tourism impacts and found that on average, it took 12 to 28 months to return to baseline visitor spending. There is likely to be significant impacts to the tourism industry, wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up and change in any public misconceptions regarding the spill (Oxford Economics, 2010).
	Cultural Heritage There are a number of historic shipwrecks identified in the vicinity of the PAA. Shipwrecks occurring in the subtidal zone will be exposed to entrained and dissolved hydrocarbons and marine life that shelter and take refuge in and around these wrecks may be affected by in-water toxicity of dispersed hydrocarbons. The consequences of such hydrocarbon exposure may include all or some of: • large fish species moving away. • resident fish species and sessile benthos such as hard corals exhibiting sub-lethal and lethal impacts (which may range from physiological issues to mortality). Entrained hydrocarbons above threshold concentrations (>500 g/m^2) are predicted at Ningaloo Coast. It is acknowledged that the area contains numerous Indigenous sites such as burial grounds, middens and fish traps that provide a historical account of the early habitation of the area and a tangible part of the culture of local Indigenous groups. Additionally, artefacts, scatter and rock shelter are contained on Barrow and Montebello islands (surface hydrocarbons or accumulated hydrocarbons are also predicted for these areas). Within the wider ZoC a number of places are designated World, National and Commonwealth heritage places. These places are also covered by other designations such as WHA, marine parks, and listed shipwrecks. Potential impacts have; therefore, been discussed in the sections above.

Summary of potential impacts to environmental values(s)
In the unlikely event of a major hydrocarbon spill due to a loss of well integrity, the ZoC includes the areas listed in **Table 12-12**, including the sensitive marine environments and associated receptors of the Muiron Islands, Ningaloo Coast, Rankin Bank, Rowley Shoals, Glomar Shoals, Montebello/Barrow/Lowendal Islands Group, Bwernier and Dorre Islands, the Pilbara Southern Islands Groups, Shark Bay, and the Abrolhos Islands and any sensitive receptors in the open waters amongst these key receptor locations. In summary, long term impacts may occur at sensitive nearshore and shoreline habitats, particularly, areas of the Barrow and Montebello Islands, as a result of a major spill of hydrocarbon from drilling activities within the Permit Area. The overall environmental consequence is defined as B 'Major, long term impact (10-50 years) on highly valued ecosystem, species, habitat, physical or biological attributes'. The likelihood of the event is defined as a '2' Unlikely' resulting in a risk ranking of high.

Summary of Control Measures
• Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011: Accepted Well Operations Management Plan (WOMP) and application to drill. • The Well Acceptance Criteria Procedure details the as-built checks that shall be completed during well operations to establish a minimum acceptable standard of well integrity is achieved. • Woodside Suspension and Abandonment Procedure. • The Well Blowout Contingency Planning Procedure details specifications for well design to assess the feasibility of performing a well kill operation. • Subsea BOP specification and function testing is undertaken in accordance with internal Woodside Standards and international requirements: - OEM Standards - Engineering Standard – Rig Equipment - Drilling and Completions - Well Control Manual - API Standard 53 4th Edition. • Implement slimmer well design on all wells to reduce blowout volumes (i.e. drill cretaceous claystones in 8 ½" hole size). • Engineering Standards – Rig Equipment and Engineering Standard - Mobile Offshore Drilling Unit Mooring Design require that a mooring analysis report be undertaken and implemented for anchor deployment.

Accidental Hydrocarbon Release: Vessel Collision

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Loss of hydrocarbons to marine environment due to a vessel collision (e.g. support vessels or other marine users).			X		X	X	X	A	D	1	M	LCS GP PJ	Broadly Acceptable	EPO 13

Description of Source of Risk

Background

There will most likely be at least one support vessel in the vicinity of the MODU during drilling operations. This temporary presence in the area will result in a navigational hazard for commercial shipping within the immediate area. This navigational hazard could result in a third party vessel colliding with the MODU which could result in a loss of well containment.

The MODU has a total marine diesel capacity of approximately 966 – 1400 m^3 that is distributed through a number of isolated tanks. MODU fuel tanks are located in the MODU pontoons, typically located on the inner sides of pontoons and can be over 10 m below the waterline.

The marine diesel storage capacity of a support vessel can also be in the order of 1000 m^3 (total) that is distributed through multiple isolated tanks typically located mid-ships and can range in typical size from 22 to 105 m^3.

A typical ISV vessel is likely to have multiple isolated fuel tanks distributed throughout the hull of the vessel. Individual fuel tanks are typically 500 m^3 in volume. In the unlikely event of a vessel collision involving an ISV during the Petroleum Activities Program, the vessels will have the capability to pump fuel from a ruptured tank to a tank with spare volume in order to reduce the potential volume of fuel released to the environment.

Industry Experience

Registered vessels or foreign flag vessels in Australian waters are required to report events to the Australian Transport Safety Bureau (ATSB), AMSA or Australian Search and Rescue (AusSAR).

From a review of the ATSB marine safety and investigation reports, one vessel collision occurred in 2011-12 that resulted in a spill of 25-30 L of oil into the marine environment as a result of a collision between a tug and support vessel off Barrow Island. Two other vessel collisions occurred in 2010, one in the port of Dampier, where a support vessel collided with a barge being towed. Minor damage was reported and no significant injury to personnel or pollution occurred. The second 2010 vessel collision involved a vessel under pilot control in port connected with a vessel alongside a wharf causing it to sink. No reported pollution resulted from the sunken vessel. These incidents demonstrate the likelihood of only minor volumes of hydrocarbons being released during the highly unlikely event of a vessel collision occurring.

From 2010 to 2011, the ATSB's annual publication defines the individual safety action factors identified in marine accidents and incidents: 42% related to navigation action (2011). Of those, 15% related to poor communication and 42% related to poor monitoring, checking and documentation. The majority of these related to the grounding instances.

Credible Scenario

For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align as follows:

- The identified causes of vessel interaction must result in a collision.
- The collision must have enough force to penetrate the vessel hull.
- The collision must be in the exact location of the fuel tank.
- The fuel tank must be full, or at least of volume which is higher than the point of penetration.

The probability of the chain of events described above aligning, to result in a breach of fuel tanks resulting in a spill that could potentially affect the marine environment is considered remote. Given the offshore location of the Permit Area, vessel grounding is not considered a credible risk.

The environmental risk analysis and evaluation undertaken identified and assessed a range of potential scenarios that could result in a loss of vessel structural integrity resulting in damage to fuel storage tank(s) and a loss of marine diesel to the marine environment (**Table 12-13**). The scenarios considered damage to single and multiple fuel storage tanks in the support vessel, ISV and MODU due to dropped objects and various combinations of vessel to vessel and vessel to MODU collisions. In summary:

1. It is not a credible scenario that the total storage volume of the MODU would be lost, as fuel is stored in more than one tank.
2. It is not a credible scenario that a storage tank on the MODU would be damaged due to the location of the tanks within the hull, behind the bilge tanks, below the waterline.
3. It is not a credible scenario that a collision between the support vessel and MODU would damage any storage tanks, due to the location of the tanks on both vessel types, and secondary containment.
4. It is highly unlikely that the full volume of the largest storage tank on a support vessel or ISV would be lost.

The last scenario considered was a collision between the support vessel or ISV with a third party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels). This was assessed as being credible but highly unlikely given the standard vessel operations and equipment in place to prevent collision at sea, the short duration of ISV operations in the PAA, the standby role of a support vessel (low vessel speed) and its operation in close proximity to the MODU (exclusion areas) and the construction and placement of storage tanks. The largest tank of the support vessel is unlikely to exceed 105 m^3; the largest tank volume of an ISV is unlikely to exceed 500 m^3.

Table 12-13: Summary of credible hydrocarbon spill scenario as a result of vessel collision

Scenario	Hydrocarbon Volumes	Preventative and Mitigation Controls	Credibility
Breach of MODU fuel tanks due to support vessel collision.	MODU has a fuel oil storage capacity of approximately 966–1400 m^3, distributed through multiple tanks.	Fuel tanks are located on the inside of pontoons and protected by location below water line, protection from other tanks, e.g. bilge tanks. The draught of vessel and location of tanks in terms of water line prevent the tanks from being breached.	**Not credible** Due to location of tanks.
Breach of support vessel fuel tanks due to collision with MODU.	Activity support vessel has multiple marine diesel tanks typically ranging between 22–105 m^3 each.	Typically, double wall, tanks which are located mid ship (not bow or stern). Slow support vessel speeds when in close proximity to MODU.	**Not credible** Collision with MODU at slow speeds is highly unlikely and if did occur is highly unlikely to result in a breach of support vessel (low energy contact from slow moving vessel).
Breach of ISV fuel tanks during CAN	ISV support vessel has multiple isolated tanks,	Tank locations midship (not bow or stern).	**Credible** ISV – third party vessel

installation due to collision with third party vessel, including commercial shipping and fishing.	largest volume of a single tank is likely to be <500 m^3.	For the majority of CAN the installation vessel will be holding location.	collision could potentially result in the release form a fuel tank.
Breach of support vessel fuel tanks due to support vessel – other vessel collision including commercial shipping/fisheries.	Activity support vessel has multiple marine diesel tanks typically ranging between 22–105 m^3 each.	Typically double wall, tanks which are located midship (not bow or stern). Vessels are not anchored and steam at low speeds when relocating within the Permit Area or providing stand-by cover. Normal maritime procedures would apply during such vessel movements.	**Credible** Activity support vessel – other vessel collision could potentially result in the release from a fuel tank.
Loss of well control due to third party vessel (e.g. large bulk carrier) collision with MODU during drilling activities.	Loss of containment of reservoir fluids for estimated volumes.	preventative and mitigation controls.	**Credible** Activity support vessel – other vessel collision could potentially result in the release from a fuel tank.
Dropped object from back-loading/ offloading operations rupturing the MODU fuel tanks (e.g. a container or piece of equipment).	MODU has a fuel oil storage capacity of approximately 966-1400 m^3, distributed through multiple tanks.	Fuel tanks are located on the inside of pontoons and protected by location below water line, protection from other tanks, e.g. bilge tanks. The draught of vessel and location of tanks in terms of water line prevent the tanks from being breached.	**Not credible** No direct pathway to tanks from dropped objects.

Hydrocarbon Characteristics

Marine diesel is a mixture of both volatile and persistent hydrocarbons. Predicted weathering of marine diesel, based on typical conditions in the region, indicates that approximately 50% by mass would be expected to evaporate over the first day or two (**Figure 12-6**). After this time the majority of the remaining hydrocarbon is entrained into the upper water column. In calm conditions entrained hydrocarbons are likely to resurface. Up to 95% of the spill volume is expected to evaporate over time (**Figure 12-6**). The remaining 5% is persistent and will reduce in concentration through degradation and dissolution.

Given the environmental conditions experienced in the PAA, marine diesel is expected to undergo rapid spreading and this, together with evaporative loss, is likely to result in a rapid dissipation of the spill. Marine diesel distillates tend not to form emulsions at the temperatures found in the region. The characteristics of the marine diesel used in the modelling are given in **Table 12-14**.

Table 12-14: Characteristics of the marine diesel used in the modelling

Hydrocarbon Type	Initial Density (g/cm^3) at 25˚C	Viscosity (cP @ 25˚C)	Component BP (˚C)	Volatiles <180	Semi volatiles 180–265	Low Volatility (%) 265-380	Residual (%) >380
				Non-Persistent			Persistent
Marine Diesel	0.829	4.0	% of total	6	34.6	54.4	5

(surrogate for marine gas oil – MGO)							

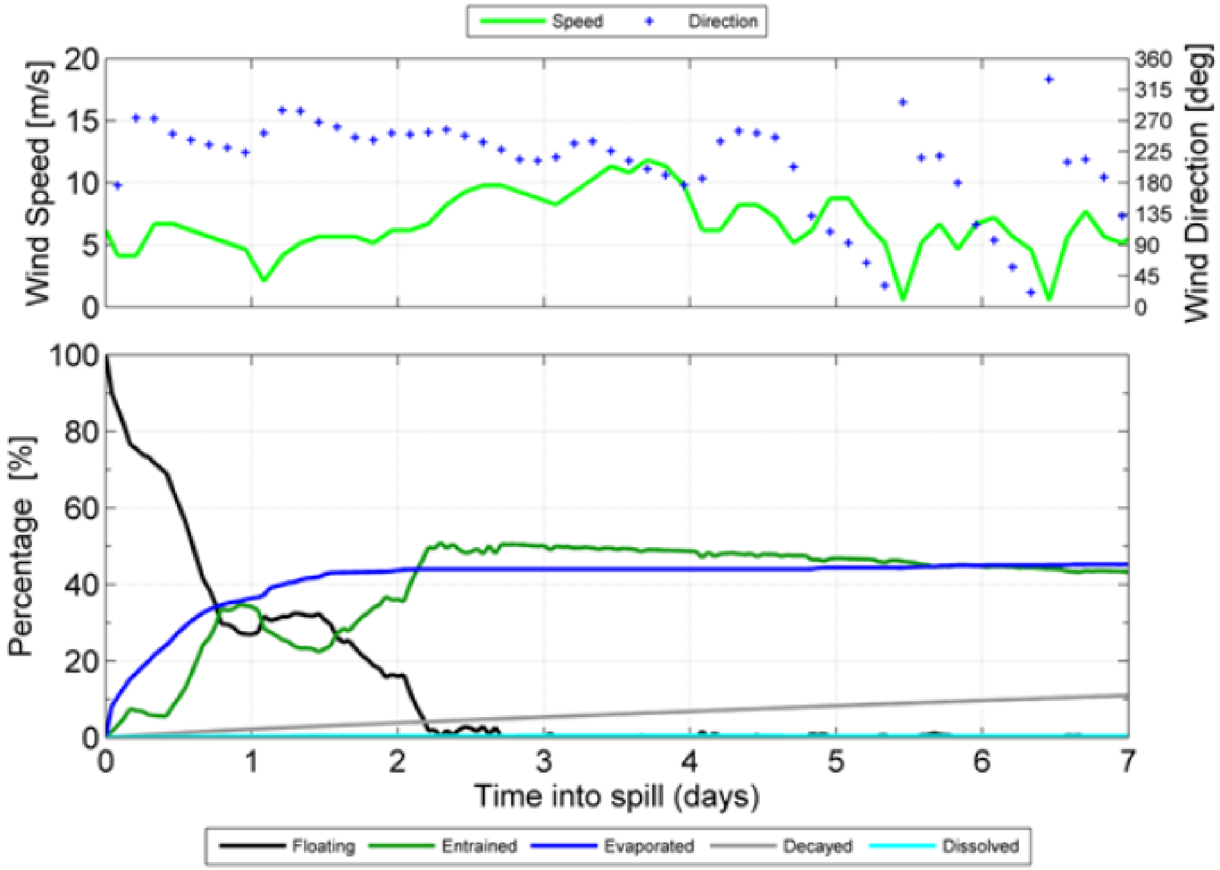

Figure 12-6: Proportional mass balance plot representing weathering of a surface spill of marine diesel as a one-off release (50 m^3 over 1 hr) and subject to variable wind at 27 °C water temperature and 25 °C air temperature.

Impact Assessment

Modelling conducted by APASA identified that at the furthest point, surface hydrocarbons could be found 35 km from the spill site at 10 g/m^2, and entrained diesel >500 ppb could be detected ~200 km from the release site. No dissolved aromatic hydrocarbons >500ppb are found anywhere in the model domain and no receptor is predicted to receive floating or accumulated oil concentrations equal to or greater than 1 g/m^2.

Table 12-15 and **Table 12-16** provide details of receptors potential contacted by entrained diesel at 500 ppb.

Taking into consideration the ZoC derived from hydrocarbon spill modelling for a marine diesel spill the environment that may be affected will fall with the ZoC of the crude spill.

Table 12-15: Potential receptors contacted by entrained diesel <500 ppb

Receptor	Probability (%) of entrained oil concentration ≥500 ppb	Minimum time to receptor (hours) for entrained oil at ≥500 ppb	Maximum entrained oil concentration (ppb) averaged over all replicate simulations	Maximum entrained oil concentration (ppb), at any depth, in the worst replicate simulation
Montebello AMP	5	52	61	2,577
Montebello MP	1	118	12	653

Gascoyne AMP	<1	NC	3	183
Argo Rowley Terrace AMP	<1	NC	3	273
Barrow Island	1	140	13	666
Glomar Shoals	<1	95	18	7
Montebello Islands	1	126	11	653
Murion Island MMA	<1	NC	3	165
Murion Islands	<1	NC	3	160
Ningaloo AMP	<1	NC	2	118
Ningaloo Coast North WHA	<1	NC	2	118
Ningaloo Coast North	<1	NC	<1	67
Ningaloo Coast Middle WHA	<1	NC	<1	92
Pilbara Islands – Southern Island Group	<1	NC	11	468
Rankin Bank	<1	162	14	28
WA Coastline	1	127	11	653

Table 12-16: Zone of Consequence – Key Receptor Locations and Sensitivities with the Summary Hydrocarbon Spill Contact for an instantaneous release of marine diesel

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon contact and fate (≥1% probability)			
		Physical		Biological																							Socio-economic and Cultural							
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species										Other Species									
		Open water – (pristine)	Marine Sediment - (pristine	Coral reef	Seagrass beds/Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non biogenic coral reefs	Offshore filter feeders and/or Deepwater	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and	Seasnakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas/Heritage – European and	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
Offshore[6]	Commonwealth	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓	X	X		

[6] Note: hydrocarbons cannot accumulate on open ocean, submerged receptors, or receptors not fully emergent

	waters																																	
	Montebello AMP	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓*			X		
	Ningaloo AMP	✓						✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓			X		
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			X		
Islands	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		X		
Mainland (nearshore waters)	WA Coastline	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		X		

Summary of Potential Impacts to environmental values(s)
No receptors are contacted by dissolved aromatic hydrocarbons >500 ppb or floating/accumulated oil concentrations equal to or greater than 1 g/m^2. Entrained hydrocarbons >500 ppb may contact receptors, with the greatest likelihood and contractions found at the Montebello/Barrow Islands complex and associated protected areas. Weathering of surface diesel shown in **Figure 12-6** is similar to that shown for Egret-3 crude, although for marine diesel, the percentage of surface oil decreases more quickly and shows greater entrainment compared to Egret-3 crude. Furthermore, the loss of containment ZoC is larger spatially than the marine diesel ZoC and therefore the potential impacts of entrained**,** and the scale of impact described, provides a conservative assessment for potential impacts of a 500 m^3 release of marine diesel due to vessel collision. In the unlikely event of an unplanned hydrocarbon release to the marine environment due to vessel collision, combined with the adopted controls, it is considered that any potential impact would be localised, low and temporary in nature to water quality in comparison to background levels and/or international standards with localised, low and temporary impacts to habitats, populations and shipping/fishing concerns. The highest environmental consequence identified for the assessment of an unplanned hydrocarbon release to the marine environment due to vessel collision, is defined as E, which equates to 'Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes'.
Summary of Potential Impacts to environmental values(s)
• Marine Orders 30 (Prevention of Collisions) 2016. • Marine Order 21 (Safety of navigation and emergency procedures) 2016. • Establishment of a 500 m petroleum safety zone around MODU and ISV (during CAN installation) and communicated to marine users. • A support vessel is on standby during drilling activities to communicate with third-party vessels and assist in maintaining the petroleum safety zone. • The support vessel will undertake the actions to prevent unplanned interactions. • Notify Australian Hydrographic Service (AHS) of activities and movements prior to the MODU being on location. • Notify AMSA JRCC of activities and movements.

Accidental Hydrocarbon Release: Bunkering

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk	ALARP Tools	Acceptability	Outcome
Loss of hydrocarbons to marine environment from bunkering/refuelling.			X			X		A	F	2	L	LCS GP PJ	Broadly Acceptable	EPO 14

Description of Source of Risk

Bunkering of marine diesel between the support vessel/s and the MODU or ISV occurs at the drilling location. Additionally, refuelling of helicopters using aviation jet fuel may take place onboard the MODU.

Three credible scenarios for the loss of containment of marine diesel during bunkering operations were identified:

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be in the order of less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break coupling and complete loss of hose volume).
- Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, resulting in approximately 8 m^3 marine diesel loss to the deck and/or into the marine environment.
- Partial or total failure of a bulk transfer hose or fittings during helicopter refuelling could spill aviation jet fuel to the helicopter deck and/or into the marine environment. All helicopter refuelling activities are closely supervised and leaks on the helideck are considered to be easily detectable. In the event of a leak, transfer would cease immediately. The credible volume of such a release during helicopter refuelling would be in the order of <100 L.

Quantitative Spill Risk Assessment

Given the physical and chemical similarities, and the relatively small credible spill volumes, marine diesel is considered to be a suitable substitute for aviation jet fuel for the purposes of this environmental risk assessment. Woodside has commissioned RPS to model several small marine diesel spills, including surface spill volumes of 8 m^3 in the offshore waters of northwest WA. The results of these models have indicated that exposure to surface hydrocarbons above the 10 g/m^2 threshold is limited to the immediate vicinity of the release site, with little potential to extend beyond 1 km. Therefore, it is considered that exposure to thresholds concentrations from an 8 m^3 surface spill from bunkering activities would be well within the ZoC for the vessel collision scenario. Given this, the offshore location of the Permit Area, and the fact that the same hydrocarbon type is involved for both scenarios, specific modelling for an 8 m^3 marine diesel release was not undertaken for this Petroleum Activities Program.

Hydrocarbon Characteristics

Refer to diesl spill section for a description of the characteristics of marine diesel, including detail on the predicted fate and weathering of a spill to the marine environment.

Impact Assessment

Previous modelling studies for 8 m^3 marine diesel releases, spilled at the surface as result of bunkering

activities, indicated that the potential for exposure to surface hydrocarbons exceeding 10 g/m^2 was confined to within the immediate vicinity (approximately 1 km) of the release sites. Therefore, it is considered that there is no potential for contact with sensitive receptor locations above surface (10 g/m^2), entrained (500 ppb) or dissolved (500 ppb) threshold concentrations from an 8 m^3 spill of marine diesel within the Permit Area.
Summary of Potential Impacts to protected species and water quality
Further detail on impacts specific to a spill of marine diesel from a bunkering loss are provided below. The biological consequences of such a small volume spill on identified open water sensitive receptors relate to the potential for minor impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area and no impacts to commercial fisheries are expected. Potential impacts of unplanned hydrocarbon release to the marine environment from vessel collision) for the detailed potential impacts; however, the extent of the ZoC associated with a marine diesel spill from loss during bunkering will be much reduced in terms of spatial and temporal scales, and hence, potential impacts from bunkering are considered very minor.
Summary of Control Measures
• Marine Order 91 (Marine pollution prevention – oil) 2018. • Engineering Standard - Rig Equipment details requirements for the management of bunkering equipment. • The contractor bunkering/helicopter refuelling procedures specify control measures to be implemented during bunkering/refuelling operations.

Unplanned Discharges: Drilling Fluid

Impacts and Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Accidental discharge of drilling fluids (WBM/NWBM/base oil) to marine environment due to failure of slip joint packers, bulk transfer hose/fitting, emergency disconnect system or from routine MODU operations.		X	X		X	X		A	F	1	L	LCS GP PJ	Broadly acceptable	EPO 15

Description of Source of Risk

Transfers

A support vessel will undertake bulk transfer of mud or base oil to the MODU, if and when required. Failure of a transfer hose or fittings during a transfer or backload, as a result of an integrity or fatigue issue, could result in a spill of mud or base oil to either the bunded deck or into the marine environment.

Similar to a spill event during refuelling, the most likely spill volume of mud is likely to be less than 0.2 m^3 based on the volume of the transfer hose and the immediate shutoff of the pumps by personnel involved in the bulk transfer process. However, the worst-case credible spill scenario could result in up to 8 m^3 of mud being discharged. This scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures requiring transfer activities to be monitored, coupled with a failure to immediately shut off pumps (e.g. mud pumped through a failed transfer hose for a period of approximately five minutes).

Slip Joint Packer Failure

The slip joint packer enables compensation for the dynamic movement of the MODU (heave) in relation to the static location of the BOP. A partial or total failure of the slip joint packer could result in a loss of mud to the marine environment. The likely causes of this failure include a loss of pressure in the pneumatic (primary) system combined with loss of pressure in the back up (hydraulic) system.

Catastrophic sequential failure of both slip joint packers (pneumatic and hydraulic) would trigger the alarm and result in a loss of the volume of fluid above the slip joint (conservatively 1.5 m^3) plus the volume of fluid lost in the one minute (maximum) taken to shut down the pumps. At a flow rate of 1000 gallons per minute this volume would equate to an additional 3.8 m^3. In total, it is expected that this catastrophic failure would result in a loss of 5.3 m^3.

Failure of either of the slip joint packers at a rate not large enough to trigger the alarms could result in an undetected loss of 20 bbl (3 m^3) maximum assuming a loss rate of 10 bbl/hr and that MODU personnel would likely walk past the moon pool at least every two hours.

Activation of the EDS

The emergency disconnect sequence (EDS) is an emergency system that provides a rapid means of shutting in the well (i.e. BOP closed) and disconnecting the MODU from the BOP. There are two main scenarios where the EDS could be activated: (1) automatic activation of the EDS due to a loss of MODU station keeping resulting from loss of multiple moorings; and (2) manual activation of the EDS due to an identified threat to the safety of the MODU including potential collision by a third-party vessel or a loss of well control.

The activation of the EDS can result in the release of the entire volume of the marine riser to the marine environment. When drilling, this could result in a subsurface release of a combination of mud (including NWBM) and cuttings at the seabed and a release of base fluid. The volume of material released depends on the water depth and hence, the length of the riser (the entire riser volume would be lost). It is expected the weight of NWBM would result in the majority of the release settling to the seabed and/or remaining at depth within the water column. The base oil of the NWBM would remain in an emulsion with the other components of the mud system and drill cuttings.

Base Oil

The selection of a NWBM drilling fluid system will be based on Woodside processes; however, for the purposes of this risk assessment an example base oil (Saraline 185V) has been used. Saraline 185V is a mixture of volatile to low volatility hydrocarbons. Predicted weathering of base oil, based on typical conditions in the region, indicates that approximately 50% by mass is predicted to evaporate over the first day or two (refer to **Table 12-17**). At this time the majority of the remainder could be entrained into the water column, in calm conditions entrained hydrocarbons are likely to resurface with up to 100% will be able to evaporate over time.

Table 12-17: Characteristics of the non-water based mud base oil

Oil Type	Initial Density (kg/m³)	Viscosity (cP @ 20°C)	Volatiles (%)<180	Semi Volatiles (%)180–265	Low Volatility (%) 265-380	Residual (%) >380	Aromatic (%) of whole oil <380 °C BP
			Non-Persistent		Persistent		
Base oil (Saraline 185V)	0.7760	2.0 @ 40ºC	8.5	41.1	50.4	0	0

Impact Assessment

Potential Impacts to water quality, other habitats and communities and protected species

Base oil has a high volatile to semi-volatile fraction. If released to the marine environment at surface, this generally evaporates within the first 48 hours, with the remaining fraction being on the sea surface and weathering at a slower rate. As a result of this volatility, combined with the worst-case credible spill scenario volumes (8 m^3), and based on Woodside's experience of modelling base oil, it is considered there would be an extremely small footprint area associated with any release. Therefore, any surface oil would be confined to open waters with a minor surface slick that would not reach any sensitive receptors. Therefore impacts on water quality would be minor and temporary in nature. The safety data sheet (SDS) for Saraline 185V indicates that it is readily biodegradable, non-toxic in the water column and has low sediment toxicity (Shell, 2014).Marine fauna may be affected if they come in direct contact with a release (i.e. by traversing the immediate spill area), but due to the small footprint of such a spill, it is anticipated that any impacts would be negligible and temporary in nature.

WBM is made up of a number of components, including a variety of chemicals, incorporated into the selected drilling fluid system to meet specific technical requirements. If released to the marine environment at surface there would be an extremely small impact footprint area associated with a release. Any release would be confined to the open waters of the PAA that would not reach any sensitive receptors. Components of the WBM would settle out in the water column and be subject to dilution. Given the low toxicity of WBM and its planned discharge during drilling, any impacts on water quality would be minor and temporary in nature.

The ZoC associated with the release of NWBM from the activation of the EDS would be small, and limited to deeper water seabed surrounding the well site (the release point). The environmental consequence of such a release would include a highly localised area at the discharge location. Lethal impacts to the underlying infauna may occur but are considered unlikely, and recolonisation would occur over time. Elevated hydrocarbon and metal concentrations in the localised area of deposition would also occur, with reduction over time. It is likely that any impacts to water and sediment quality and low-sensitivity deeper water benthos would be short term, localised and a full recovery expected.

Summary of Potential Impacts to environmental values(s)

Given the adopted controls, it is considered that accidental discharge of NWBM/base oil or water based mud will not result in a potential impact to protected species and water quality greater than E with no significant impact on environmental receptors predicted. It is considered that the release of NWBM cuttings from an unplanned discharge will not result in a potential impact greater than negligible and/or temporary contamination above background levels, water quality standards, or known effect concentrations.

Summary of Control Measures
• Engineering Standard - Rig Equipment which specifies requirements for deck drainage and management of oily water for MODU. • Engineering Standard - Rig Equipment which specifies requirements for the MODU marine riser's telescopic joint. • Chemical Selection and Assessment Environment Guideline for selection of drilling, completions, cementing and sub-sea control fluids and additives. • Environmental Performance Standards Procedure which restricts overboard bulk discharge of NWBM. • Mud transfers onto, around and off the MODU shall be managed using contractor procedures. • Woodside NWBM/base oil Start-up Checklist Parts 1 and 2.

Unplanned Discharges: Deck, Subsea Spills from ROV and spills from DST

Impacts and Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Accidental discharge to the ocean of other hydrocarbons/chemicals from MODU or support vessel deck activities and equipment (e.g. cranes) including helicopter refuelling and subsea ROV hydraulic leaks.			X		X	X		A	E	1	L	LCS GP PJ	Broadly acceptable	EPO 16
Accidental discharge to the ocean of hydrocarbons during DST if the flare is extinguished.			X		X	X		A	E	1	L			

Description of Source of Risk

Deck spills can result from spills from stored hydrocarbons/chemicals or equipment. Support vessels, ISVs and the MODU typically store hydrocarbon/chemicals in various volumes (20 L, 205 L; up to approximately 4000–6000 L). Storage areas are typically set up with effective primary and secondary bunding to contain any deck spills. Releases from equipment are predominantly from the failure of hydraulic hoses, which can either be located within bunded areas or outside of bunded or deck areas (e.g. over water on cranes). Helicopter refuelling may also take place within the PAA, on the helipad of the MODU.

Minor leaks during wireline activities (a contingent activity) with a live well are described to include leaks such as:

- leaks from the lubricator, stuffing box and hose or fitting failure, which are expected to be less than 10 L (0.01 m^3)
- loss of containment - fluids - surface holding tanks
- backloading of raw slop fluids in an Intermediate Bulk Container/s (IBC)
- stuffing box leak/under pressure
- draining of lubricator contents
- excess grease/lubricant leaking from the grease injection head. Wind Blown lubricant dripping from Cable/on deck.
- lubricant used to lubricate hole.

Woodside’s operational experience demonstrates that spills are most likely to originate from hydraulic hoses and have been less than 100 L, with an average volume <10 L. Subsea spills can result from a loss of containment of fluids from subsea equipment including the BOP or ROVs. A review of these spills to the marine environment in the past 12 months showed the largest subsea spill was approx. 3 L of hydraulic fluid in Woodside’s Drilling function

The ROV hydraulic fluid is supplied through hoses containing approximately 20 L of fluid. Hydraulic lines to the ROV arms and other tooling may become caught resulting in minor leaks to the marine environment. Small volume hydraulic leaks may occur from equipment operating via hydraulic controls subsea (subsea control fluid). These include the diamond wire cutter, bolt tensioning equipment, ROV tooling, etc.

Hydrocarbons can be spilled to the marine environment during DST if the flare is extinguished.

Impact Assessment
Potential Impacts to water quality, other habitats and communities and protected species
Accidental spills of hydrocarbons or chemicals from the MODU, ISV, support vessels and drop out of hydrocarbons during DST will decrease the water quality in the immediate area of the spill; however, the impacts are expected to be temporary and very localised due to dispersion and dilution in the open ocean environment. Given the offshore/ open water location, receptors such as marine fauna may be affected if they come in direct contact with a release (i.e. by traversing the immediate spill area). In the event that marine fauna come into contact with a release they could suffer fouling, ingestion, inhalation of toxic vapours, irritation of sensitive membranes in the eyes, mouth, digestive and respiratory tracts and organ or neurological damage. Cetaceans may exhibit avoidance behaviour patterns and given they are smooth skinned, hydrocarbons and other chemicals are not expected to adhere. Given the small area of the potential spill and the dilution and weathering of any spill the likelihood of ecological impacts to marine fauna (protected species), other communities and habitats is likely to be negligible to very minor. No impacts on socio-economic receptors are expected due to the low levels of fishing activity in the PAA, the small volumes of hydrocarbons/chemicals that could be accidentally spilt and the localised and temporary nature of the impacts.
Summary of Potential Impacts to environmental values(s)
Given the adopted controls, it is considered that other hydrocarbon/chemical spills to the marine environment will not result in a potential impact greater than slight, short term local impacts on species, habitat (but not affecting ecosystems function), physical and biological attributes (i.e. Environment Impact - E).
Summary of Control Measures
• Marine Order 91 (Marine pollution prevention – oil) 2018. • The Australian Government Civil Aviation Safety Authority CAAP 92-4(0) 'Guidelines for the development and operation of off-shore helicopter landing sites, including vessels'. • MODU/ISV procedures for chemical storage and handling. • Engineering Standard – Rig Equipment details deck drainage system requirements. • Engineering Standard – Rig Equipment which includes requirements for onboard spill kits.

Unplanned Discharged: Loss of Solid Hazardous and Non-hazardous Wastes/Equipment

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Accidental loss of hazardous or non-hazardous wastes/ equipment to the marine environment (excludes sewage, grey water, putrescible waste and bilge water).			X		X	X		A	F	2	L	LCS GP PJ	Broadly acceptable	EPO 17

Description of Source of Risk
The project vessels will generate a variety of solid wastes including packaging and domestic wastes such as aluminium cans, bottles, paper and cardboard. Hence, there is the potential for solid wastes to be lost overboard to the marine environment. Woodside's Drilling function has not reported any significant loss of solid wastes to the marine environment during the past 12 months of operations. Equipment that has been recorded as being lost (primarily windblown or dropped overboard) have included the loss of a metal pole and hardhat These have occurred during backloading activities, periods of adverse weather and incorrect waste storage.

Impact Assessment

Potential Impacts to water quality, other habitats and communities, and protected species

The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the environment and secondary impacts relating to potential contact of marine fauna with wastes, resulting in entanglement or ingestion and leading to injury and death of individual animals. The temporary or permanent loss of waste materials into the marine environment is not likely to have a significant environmental impact, based on the location of the PAA, the types, size and frequency of wastes that could occur and species present.

Summary of Potential Impacts to environmental values(s)

Given the adopted controls, it is considered that the accidental discharge of solid waste described will result in localised impacts not significant to environmental receptors (i.e. Environment Impact - F).

Summary of Control Measures

- Marine Orders 95 – pollution prevention – Garbage (as appropriate to vessel class).
- Drilling and Completions Waste Management Plan, which include requirements for waste.
- ISV Waste Management Plan.
- The MODU ROV, crane or support vessel used to attempt recovery of solid wastes lost overboard.

Physical Presence: Vessel Collision with Marine Fauna

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Accidental collision between project vessels and threatened and migratory whale species.						X		A	E	1	L	LC S GP PJ	Broadly Acceptable	EPO 18

Description of Source of Risk
The MODU, ISV and support vessels operating in and around the PAA may present a potential hazard to cetaceans (e.g. humpback whales, pygmy blue whales) and other protected marine fauna such as whale sharks and marine reptiles. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction) and mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours. Support vessels are typically stationary or moving at low speeds when supporting drilling operations; support vessels typically transit to and from the PAA between two and four trips per week (e.g. to port) when the MODU is present in the PAA

Impact Assessment

Potential Impacts to protected species

The likelihood of vessel/whale collision being lethal is influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber, 2004; Laist *et al*., 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots.

Support vessels within the PAA are likely to be travelling less than 8 knots; therefore, the chance of a vessel collision with protected species resulting in lethal outcome is reduced. No known key aggregation areas (resting, breeding or feeding) are located within or immediately adjacent to the PAA. Although, the PAA does not overlap with the migration BIA for pygmy blue whales or humpback whales, the overlap with the distribution BIA for pygmy blue whales, and the close proximity of the PAA to the humpback whale migration BIA, it is possible that these species will occur in the vicinity of the PAA at various times during the year, with increased numbers during peak periods.

According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk is less than 10% at a speed of 4 knots. Vessel-whale collisions at this speed are uncommon and, based on reported data contained in the US National Ocean and Atmospheric Administration database (Jensen and Silber, 2004) there are only two known instances of collisions when the vessel was travelling at less than 6 knots, both of these were from whale watching vessels that were deliberately placed amongst whales.

Whale sharks are at risk from vessel strikes when feeding at the surface or in shallow waters (where there is limited option to dive). Whale sharks may traverse offshore NWS waters including the PAAs during their migrations to and from Ningaloo Reef and the PAA overlaps with the foraging BIA for this species. However, it is expected that whale shark presence within the PAA would not comprise significant numbers given there

is no main aggregation area within the vicinity of the PAA, and their presence would be transitory and of a short duration. Marine mammals and fish are at risk of mortality through being caught in thrusters during station keeping operations (dynamic positioning). The risk of marine life getting caught in operating thrusters is unlikely, given the low presence of individuals, combined with the avoidance behaviour commonly displayed during dynamic positioning operations. The PAA does not overlap any marine turtle BIAs or critical habitat, combined with the absence of potential foraging habitat (e.g. reef habitat or shallow shoals), it is considered that the PAA is unlikely to represent important habitat for marine turtles, although individuals may transit the area. It is unlikely, that vessel movement associated with the Petroleum Activities Program will have a significant impact on marine fauna populations given (1) the low presence of transiting individuals, (2) avoidance behaviour commonly displayed by whales and turtles and (3) low operating speed of the support vessels (generally less than 8 knots or stationary, unless operating in an emergency).
Summary of Potential Impacts to environmental values(s)
Given the adopted controls, it is considered that a collision, were it to occur, will not result in a potential impact greater than slight, short term impact on species (i.e. Environment Impact – E).
Summary of Control Measures
• EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, and OneMarine Charterers Instructions.

Physical Presence: Loss of Station Keeping and Failure of Mooring Integrity

Impacts and Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Failure of mooring integrity leading to seabed disturbance.					X			A	E	1	L	GP PJ RBA	Broadly acceptable	EPO 19
Loss of station keeping due to failure of mooring integrity resulting in anchor drag & loss of containment from existing subsea pipelines.		X	X	X	X	X	X	B	C	1	M	LCS GP PJ RBA CS SV	Acceptable if ALARP	EPO 20

Description of Source of Risk

The MODU will be secured on station by a number of morning lines, as dictated by the mooring analysis, which are held in place by anchors deployed to the seabed. High energy weather events such as cyclones, while the MODU is on station, can lead to excessive loads on the mooring lines resulting in failure (either anchor(s) dragging or mooring lines parting). A failure of mooring integrity may lead to the mooring lines and anchors attached to the MODU being trailed across the seabed. If mooring failure is sufficient, the MODU may move of station increasing the likelihood of anchor drag across the seafloor.

For a moored MODU, as proposed for the Petroleum Activities Program personnel on-board the MODU are typically evacuated during cyclones. Woodside implements a risk-based assessment process to aid in decision making for cyclone evacuations, with the well suspended prior to MODU evacuation. Support vessels also demobilise from the PAA during the passage of a cyclone. While the MODU is temporarily abandoned, the position of the MODU is monitored remotely for any deviation. Support vessels and MODU personnel return to the PAA as soon as safe to do so following a cyclone evacuation. Operational experience indicates cyclone evacuations typically last for seven days.

Industry statistics from the North Sea show that a single mooring line failure for MODUs is the most common failure mechanism (33×10^{-4} per line per year), followed by a double mooring line failure (11×10^{-4} per line per year) (Petroleumstilsynet, 2014). Note that single and double mooring line failures do not typically result in the loss of station keeping. In the event of partial or complete mooring failures that are sufficient to result in a loss of station keeping, industry experience indicates that MODUs may drift considerable distances from their initial position (Offshore: Risk & Technology Consulting Inc., 2002). Partial mooring failures leading to a loss of station keeping resulted in smaller MODU displacements due to the remaining anchors dragging along the seabed when compared to complete mooring failures; complete mooring failures resulted in a freely drifting MODU (Offshore: Risk & Technology Consulting Inc., 2002).

NOPSEMA has recorded four cases of anchor drag due to loss of MODU holding station during cyclone activity between 2004 and 2015 (NOPSEMA, 2015).

Subsea Loss of Containment

A subsea loss of containment from a rupture of live flowlines/pipelines within and in close proximity to the PAA could occur should loss of station keeping of the MODU from mooring failure result in anchor drag across the pipeline/flowline.

Two pipelines and one flowline occur within or in close proximity to the PAA and could be credibly ruptured resulting in loss of inventory: The loss of containment from the existing Eaglehawk-1 abandoned wellhead was not considered credible.

Angel Export Pipeline

A worst case credible hydrocarbon release scenario has been defined in the Angel Facility Operations EP as the loss of the entire inventory of the Angel export pipeline, which holds the largest inventory of hydrocarbons within the Angel subsea pipeline system. This could result in a release to the environment of up to 18,549 m^3 of gas and condensate (of which approximately 210 m^3 is condensate).

Okha FPSO Production Flowline

A worst case credible hydrocarbon release scenario has been defined in the Okha Floating Production Storage and offloading Facility Operations EP as the rupture of one of the subsea production flowlines, which holds the largest inventory of hydrocarbons within the Okha facility subsea system. This could result in a release to the environment of up to 773 m^3 of oil and associated gas. This scenario is based on an instantaneous large borehole release (such as major rupture or failure of the flowline), and assumes that the entire inventory of the flowline is released plus a 10 second delay to actuation of the emergency shutdown systems (ESD), limiting further release of hydrocarbons from the wells.

TL1 Export Pipeline

A worst case credible hydrocarbon release scenario has been defined in the North Rankin Complex Operations EP as the rupture of one of the subsea hydrocarbon export trunklines (1TL Trunkline), which holds the largest inventory of hydrocarbons within the NRC subsea system. This could result in a release to the environment of up to 6500 m^3 of condensate and associated gas. This scenario is based on an instantaneous large borehole release (such as major rupture or failure of the trunkline), and assumes that the entire inventory of the flowline is released plus a ten second delay to actuation of the ESD, limiting further release of hydrocarbons from the wells.

Under Regulation 31(1) of the OPGGSE Regulations, we refer to the above accepted EPs for a full description and assessment of impacts and risks. Management controls and response capabilities are also detailed in the above EPs. Additional controls relating the operation of the MODU are provided below.

Impact Assessment

Potential Impacts to Other Benthic Communities

Benthic habitats in the PAA are expected to largely consist of fine grained muddy sands and silts with an absence of hard substrate. In the unlikely event of a cyclone resulting in the MODU breaking its moorings, the anchors could cause physical damage to soft sediment and potentially limited hard bottom habitats (i.e. Ancient Coastline KEF) and associated benthic communities (e.g. epifauna and infauna). This would result in localised short-term impacts to habitat and biological attributes. Given the low abundance, diversity and broad-scale distribution of the benthic habitat types within and adjacent to the PAA, the scale of impact will not be significant.

Potential Impacts of Hydrocarbon Release

A full impact assessment is provided in the Angel Facility Operations, Okha FPSO Operations and North Rankin Complex Operations EPs listed above. These assessments also contain details of oil spill modelling conducted. Additionally, given the volumes potentially released from the pipelines/flowlines are smaller than the loss of containment scenario, the impacts to sensitives identified in the ZoC will encompass those potential ling impacted by a pipeline/flowline rupture.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, seabed disturbance from a loss of station keeping will result in impacts to soft sediment benthic communities would result in only slight, short-term local impacts (i.e. Environment Impact - E).

Loss of station keeping due to failure of mooring integrity resulting in anchor drag and loss of containment from existing subsea pipelines would result in moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes as described in the Angel Facility Operations, Okha FPSO

Operations and North Rankin Complex Operations EPs listed above.
Summary of Control Measures
• Engineering Standard – Rig Equipment specifications and requirements for station keeping equipment (mooring systems). • MODU to be tracked when unmanned. • Engineering Standard – Rig Equipment and Engineering Standard - Mobile Offshore Drilling Unit Mooring Design require that a mooring analysis report be undertaken and implemented for anchor deployment.

Physical Presence: Distribution to Seabed from Dropped Objects

Impacts and Risks Evaluation Summary														
Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Dropped objects resulting in seabed disturbance.					X			A	F	2	L	LCS GP PJ	Broadly acceptable	EPO 20

Description of Source of Risk
There is the potential for objects to be dropped overboard from the MODU and project vessels to the marine environment. Objects that have been dropped during previous offshore projects include small numbers of personnel protective gear (e.g. glasses, gloves, hard hats), small tools (e.g. spanners) hardware fixtures (e.g. riser hose clamp) and drill equipment (e.g. drill pipe). The spatial extent in which dropped objects can occur is restricted to the PAA.

Impact Assessment

Potential Impacts to Other Benthic Communities

In the unlikely event of loss of equipment or materials to the marine environment, potential environmental effects would be limited to localised physical impacts on benthic communities. As a result of recovery of any dropped objects this impact will be temporary in nature, however, if the object cannot be recovered due to health and safety, operational constraints and other factors (locating dropped objects at depth) then the impact will be long term.

The temporary or permanent loss of dropped objects into the marine environment is not likely to have a significant environmental impact, as the benthic communities associated with the PAA are of low sensitivity and are broadly represented throughout the NWMR.

A relatively small proportion of the Ancient Coastline at 125 m Depth Contour KEF overlaps the PAA. The habitat types associated with the hard substrate that characterises the KEF are not considered to be unique by Falkner *et al*. (2009) in their review of KEFs in the NWMR. Given only a small proportion of the KEF is overlapping the PAA, and the nature and scale of impacts and risks from dropped objects, seabed sensitivities associated with this KEF will not be significantly impacted. Further, considering the types, size and frequency of dropped objects that could occur, it is unlikely that a dropped object would have a significant impact on any benthic community.

Summary of Potential Impacts to environmental values(s)

Given the adopted controls and the predicted small footprint of a dropped object, it is considered that a dropped object will result in only localised impacts to a small area of the seabed and a small proportion of the benthic population; however not significant impact to environmental receptors, and with no lasting effect and (i.e. Environment Impact - F).

Summary of Control Measures

- The MODU ROV, crane or support vessels may be used to attempt recovery of objects lost overboard, where safe and practicable.

- The MODU/ISV work procedures for lifts, bulk transfers and cargo loading.
- MODU/ISV inductions include control measures and training for crew in dropped object prevention.

Physical Presence: Accidental Introduction of Invasive Marine Species

Impacts and Risks Evaluation Summary														
Source of Risk	**Environmental Value Potentially Impacted**							**Evaluation**						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socio-Economic	Decision Type	Consequence	Likelihood	Current Risk Rating	ALARP Tools	Acceptability	Outcome
Introduction of invasive marine species (IMS).					X	X	X	A	F	0	L	LCS	Broadly Acceptable	EPO 21

Description of Source of Risk

Vessels

During the Petroleum Activities Program, vessels will be transiting to and from the Operational Areas; potentially including traffic mobilising from beyond Australian waters. These project vessels may include the MODU, ISV and activity support vessels.

All vessels are subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good attachment surfaces (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Commercial vessels typically maintain anti-fouling coatings to reduce the build-up of fouling organisms. Organisms can also be drawn into ballast tanks during onboarding of ballast water as cargo is loaded or to balance vessels under load.

Immercible Equipment

The CAN will also be transported to the Operational Areas. As there is the potential for the CAN to be used on other projects prior to use on this activity, there is the potential for IMS translocation. The CAN will be transported to the Operational Area on board the ISV (i.e. dry transport), this exposure to air, sun and high temperatures; will reduce any IMS translocation risk. Additionally it is not expected that new IMS will settle on the CAN during use for the Petroleum Activities Program in the Operational Area (see impact assessment below). This will minimise any risk of introducing IMS from the CAN.

During the Petroleum Activities Program, project vessels and the CAN have the potential to introduce IMS to the Operational Area through biofouling and IMS being carried on vessels as well as ballast water exchange (as described above). Cross contamination between vessels can also occur (e.g. IMS translocated between project vessels).

Impact Assessment

Potential Impacts to Ecosystems/Habitats, Species and Socio-economic Values

IMS are a subset of Non-indigenous Marine Species (NIMS), that have been introduced into a region beyond their natural biogeographic range resulting in impacts to social/cultural, human health, economic and/or environmental values. NIMS are species that have the ability to survive, reproduce and establish founder populations. However, not all NIMS introduced into an area will thrive or cause demonstrable impacts and the majority of NIMS around the world are relatively benign and few have spread widely beyond sheltered ports and harbours.

Potential IMS have historically been introduced and translocated around Australia by a variety of natural and human means including biofouling and ballast water. Potential IMS vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type, which dictate their survival and invasive capabilities. IMS typically require hard substrate in the photic zone; therefore, requiring shallow waters, to become established.

Once introduced, IMS may predate on local species (which had previously not been subject to this kind of predation and therefore not have evolved protective measures against the attack), they may outcompete indigenous species for food, space or light and can also interbreed with local species, creating hybrids such that the endemic species is lost. These changes to the local marine environment result in changes to the natural ecosystem.

IMS have also proven economically damaging to areas where they have been introduced and established. Such impacts include direct damage to assets (fouling of vessel hulls and infrastructure) and depletion of commercially harvested marine life (e.g. shellfish stocks). IMS have proven particularly difficult to eradicate from areas once established. If the introduction is detected early, eradication may be effective but is likely to be expensive, disruptive and, depending on the method of eradication, harmful to other local marine life.

While project vessels (i.e. MODU, ISV, activity support vessels) and CAN have the potential to introduce IMS into the Operational Area, the deep offshore open waters of the PAA (100 to 129 m), away from shorelines and/or critical habitat, more than 12 nm from shore, mean the PAA is not conducive to the settlement and establishment of IMS. Given this, the likelihood of IMS being introduced and establishing viable populations is low.

Summary of Potential Impacts to environmental values(s)

In support of Woodside's assessment of the impacts and risks of IMS introduction associated with the petroleum activity program, Woodside conducted a risk and impact evaluation of the different aspects of a marine pest translocation. The results of this assessment are presented in the table below.

As a result of this assessment Woodside has presented the highest potential consequence as a D and likelihood as Remote (0), resulting in an overall Low risk following the implementation of identified controls.

IMS Introduction Location	Credibility of Introduction	Consequence of Introduction	Likelihood
Introduced to operational area and establishment on the seafloor or subsea structures (i.e. wellheads in the event they are left in-situ).	**Not Credible** The deep offshore open waters of the PAA, away from shorelines and/or critical habitat, more than 12 nm from a shore and in waters 100–129 m deep are not conducive to the settlement and establishment of IMS.		
Introduced to operational area and establishment on a project vessel (i.e. MODU, ISV, activity support vessels) or CAN.	**Credible** There is potential for the transfer of marine pests between project vessels or the CAN within the operational area.	**Reputation and Brand – D** [7] If IMS were to establish on a project vessel (i.e. MODU, ISV, activity support vessels) this would potentially result in fouling of intakes (depending on the pest introduced), transfer of pests to other support vessels would likely result in the quarantine of the vessel or CAN until eradication could occur (through cleaning and treatment of infected areas), which would be costly to undertake. Such introduction would be expected to have minor impact to Woodside's reputation and brand, particularly with Woodside's contractors and would likely have a reputational impact on future proposals.	**Remote (0)** Interactions between project vessel will be limited during the petroleum activity program, with 500 m safety exclusion zones being adhered to around the MODU, and interactions limited short periods of time alongside (i.e. during backloading, bunkering activities or CAN installation). There is also no direct contact (i.e. they are not tied up alongside) during these activities. Spread of marine pests via ballast water or spawning in these open

[7] Note – the translocation of IMS from an "infected" MODU, ISV, activity support vessels or CAN to shallower environments via natural dispersion is not considered credible given the distances of the operational area from nearshore environments (ie 12nm/50 water depth).

			ocean environments is also considered remote.

Transfer between project vessels and by extension from project vessels to other marine environments beyond the operational area (i.e. transfer of IMS from offshore MODU to an activity support vessel and then to another environment).	**Not Credible** This risk is considered so remote that it is not credible for the purposes of the activity. The transfer of a marine pest between project vessels or the CAN was already considered remote given the offshore open ocean environment (i.e. transfer pathway discussed above). For a marine pest to then establish into a mature spawning population on the new project vessel (which would have been through Woodside's IMS process) and then transfer to another environment is not considered credible (i.e. beyond the Woodside risk matrix). Project vessels will be located in an offshore, open ocean, deep environment, where IMS survival is implausible. Furthermore this marine pest once transferred would need to survive on a new vessel with good vessel hygiene (i.e. has been through Woodside's risk assessment process), and survive the transport back from the operational area to shore. In the event it was to survive this trip, it would then need to establish a viable population in nearshore waters. It is also noted that Woodside has been conducting marine vessel movements between offshore activities and ports (such as Dampier) for a long period of time, and no IMS has been detected in these ports.

Summary of Control Measures

- All vessels will undertake ballast water exchange or treat ballast water using an approved ballast water treatment system.
- Woodside's IMS risk assessment process[8] will be applied to project vessels which enter the operational area. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS Inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.

[8] The correct management of IMS requires careful consideration of multiple complex factors. These range from an understanding of the vectors through which IMS can be introduced and spread, the maintenance and operational history of vessels and rigs proposed to be used, climatic conditions, existing baseline data of past and proposed transit and operational areas and consideration of different regulatory frameworks.
Woodside's approach simplifies the management of IMS into a standardised toolkit that includes an IMS management plan, lists of 'species of concern', risk assessment score sheets, inspection procedures and a Contractor Information Pack to ensure the risk is managed in a simple and efficient manner. Woodside's risk-based process also delivers continued value to Woodside by reducing the risk of project delays and increased operational costs, while delivering excellent marine biosecurity and environmental outcomes.
Woodside's approach has been validated through a proactive program that engaged stakeholders during development of the methodology. This included Woodside personnel, scientific input and review by experienced external IMS consultants, recognised industry experts and liaison with regulatory agencies and vessel contractors. The result is a fit-for-purpose biofouling management process that is now embedded within Woodside's marine systems, procedures and contractual requirements.

APPENDIX B: CONTROL MITIGATION MEASURES FOR POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH SPILL RESPONSE ACTIVITIES

Response activities can introduce new impacts and risks. Therefore, it is necessary to complete an environmental risk assessment process to ensure impacts and risks from response activities have been considered, practical control measures are in place to minimise impacts and risks to ALARP. A simplified assessment process has been used to complete this task which covers the identification, analysis, evaluation and treatment of impacts and risks introduced by responding to the event.

12.1 Identification of impacts and risks from implementing response strategies

Each of the control measures can modify the impacts and risks identified in the EP. These impacts and risks have been previously assessed within the scope of the EP. Refer to the EP for details regarding how these risks are being managed. They are not discussed further in this document.

- *Atmospheric emissions*
- *Routine and non-routine discharges.*
- *Physical presence, proximity to other vessels* (shipping and fisheries).
- *Routine acoustic emissions vessels.*
- *Lighting for night work/navigational safety.*
- *Invasive marine species.*
- *Collision with marine fauna.*
- *Disturbance to Seabed.*

Additional impacts and risks associated with the control measures not included within the scope of the EP but discussed below include:

- *Vessel operations and anchoring.*
- *Increase in entrained hydrocarbons.*
- *Toxicity of dispersant.*
- *Presence of personnel on the shoreline.*
- *Additional stress or injury caused to wildlife.*
- *Secondary contamination from the management of waste.*

12.2 Analysis of impacts and risks from implementing response strategies

Table 12-18 compares the adopted control measures for this activity against the environmental values that can be affected when they are implemented.

Table 12-18: Analysis of risks and impacts

	Environmental Value						
	Soil & Groundwater	**Marine Sediment Quality**	**Water Quality**	**Air Quality**	**Ecosystems/ Habitat**	**Species**	**Socio-Economic**
Monitor and evaluate		X	X		X	X	
Source control		X	X		X	X	X
Surface Dispersant Application			X		X	X	X
Subsea Dispersant Injection		X	X		X	X	X
Containment and Recovery			X		X	X	X
Shoreline Protection & Deflection	X	X	X		X	X	X
Shoreline Clean-up	X	X	X		X	X	X
Oiled Wildlife					X	X	
Scientific Monitoring	X	X	X	X	X	X	X
Waste Management	X			X	X	X	X

12.3 Evaluation of impacts and risks from implementing response strategies

Vessel operations and anchoring

Typical booms used in containment and recovery operations are designed to sit on the water surface, meaning that fauna capable of diving, such as cetaceans, marine turtles and sea snakes can readily avoid contact with the boom. Impacts to species that inhabit the water column such as sharks, rays and fish are not expected. Additionally, many fauna, such as cetaceans, are likely to detect and avoid the spill area, and are not expected to be present in the proximity of containment and recovery operations.

During the implementation of response strategies, where water depths allow, it is possible that response vessels will be required to anchor (e.g. during shoreline surveys). The use of vessel anchoring will be minimal and likely to occur when the impacted shoreline is inaccessible via road. Anchoring in the nearshore environment of sensitive receptor locations will have potential to impact coral reef, seagrass beds and other benthic communities in these areas. Recovery of benthic communities from anchor damage depends on the size of anchor and frequency of anchoring. Impacts would be highly localised (restricted to the footprint of the vessel anchor and chain) and temporary, with full recovery expected.

Distribution of entrained hydrocarbons

The application of dispersants at the surface removes hydrocarbons from surface waters, thereby reducing the risk of air breathing marine fauna (e.g. cetaceans, dugongs, marine turtles, seabirds and shorebirds) from becoming oiled and has the potential to reduce/eliminate contamination of sensitive intertidal habitats such as mangroves, coral reefs, salt marshes and sandy shores (recreational and tourist areas) through the reduction in shoreline loadings.

Chemical dispersants act to break up hydrocarbons by reducing surface tension between the hydrocarbon and the surrounding water. Dispersants, whether applied on the surface or subsea, result in the breakup of hydrocarbons into micron-sized droplets, which are easier to disperse throughout the water column. In addition, these small, dispersed hydrocarbons droplets are degraded more rapidly by bacteria due to the increased surface area presented by the droplets and therefore, the application of dispersants can enhance biodegradation and dissolution, reducing the volume of hydrocarbons that have the potential to impact shorelines.

Surface application of dispersants results in the micron-sized droplets being mixed into the upper layer of the water column, usually the first 10 to 20 m, through wave action. These elevated concentrations of dispersed hydrocarbons within the upper layer of the water column are rapidly diluted through vertical and horizontal mixing. Therefore, by dispersing surface hydrocarbons, there is a greater risk that water column and subtidal habitats could be exposed to elevated concentrations of dispersed hydrocarbons.

Toxicity of dispersants

The evaluation of the potential impacts to the receiving environment needs to consider not only the redistribution of hydrocarbons into the water column, but also the potential toxic nature of the dispersant applied and the toxicity effects of dispersed hydrocarbons.

The potential toxicity to the marine environment can be from the chemical/dispersant itself but also chemical dispersion of hydrocarbon can increase the concentration of toxic hydrocarbon compounds in the water column (Anderson et al 2014). Subtidal habitats and communities such as coral reefs, seagrass meadows, plankton, fish, known spawning grounds and periods of increased reproductive outputs (early life stages of fish and invertebrates i.e. meroplankton) are susceptible to toxic effects of chemically dispersed hydrocarbons.

Presence of personnel on the shoreline

Presence of personnel on the shoreline during shoreline operations could potentially result in disturbance to wildlife and habitats. During the implementation of response strategies, it is possible that personnel may have minimal, localised impacts on habitats, wildlife and coastlines. The impacts associated with human presence on shorelines during shoreline surveys may include:

- Damage to vegetation/habitat to gain access to areas of shoreline oiling.
- Damage or disturbance to wildlife during shoreline surveys.
- Removal of surface layers of intertidal sediments (potential habitat depletion).
- Excessive removal of substrate causing erosion and instability of localised areas of the shoreline.

Human presence for manual clean-up operations may lead to the compaction of sediments and damage to the existing environment especially in sensitive locations such as mangroves and turtle nesting beaches. However, any impacts are expected to be localised with full recovery expected.

Additional stress or injury caused to wildlife

Additional stress or injury to wildlife could be caused through the following phases of a response:

- Capturing wildlife.
- Transporting wildlife.
- Stabilisation of wildlife.
- Cleaning and rinsing of oiled wildlife.
- Rehabilitation (e.g. diet, cage size, housing density).
- Release of treated wildlife.

Inefficient capture techniques have the potential to cause undue stress, exhaustion or injury to wildlife, additionally pre-emptive capture could cause undue stress and impacts to wildlife when there are uncertainties in the forecast trajectory of the spill. During the transportation and stabilisation phases there is the potential for additional thermoregulation stress on captured wildlife. Additionally, during the cleaning process, it is important personnel undertaking the tasks are familiar with the relevant techniques to ensure that further injury and the removal of water proofing feathers are managed and mitigated. Finally, during the release phase it's important that wildlife is not released back into a contaminated environment.

Waste generation

Implementing the selected response strategies will result in the generation of the following waste streams that will require management and disposal:

- Liquids (recovered hydrocarbon/water mixture), recovered from containment and recovery and shoreline clean-up operations.
- Semi-solids/solids (oily solids), collected during containment and recovery and shoreline clean-up operations.
- Debris (e.g. seaweed, sand, woods, plastics), collected during containment and recovery and shoreline clean-up operations and oiled wildlife response.

If not managed and disposed of correctly, wastes generated during the response have the potential for secondary contamination similar to that described above, impacts to wildlife through contact with or ingestion of waste materials and contamination risks if not disposed of correctly onshore. Woodside's waste management strategy to manage the potential volumes of waste generated by the selected response strategies

Cutting back vegetation could allow additional hydrocarbon to penetrate the substrate and may also lead to localised habitat loss. However, any loss is expected to be localised in nature and lead to an overall net environmental benefit associated with the response by reducing exposure of wildlife to oiling.

12.4 Treatment of impacts and risks from implementing response strategies

The following control measures and monitoring have been adopted for the identified impacts and risks. The treatment measures identified in this assessment will be captured in Operational Plans, Tactical Response Plans, and/or First Strike Response Plans.

Vessel operations and access in the nearshore environment

- Personnel on watch for wildlife during containment and recovery operations
- Existing mooring points would be used for anchoring
- Where existing fixed anchoring points are not available, locations will be selected to minimise impact to nearshore benthic environments with a preference for areas of sandy seabed where they can be identified
- Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance on approach to the shorelines
- The boom will be monitored and maintained to ensure trapped fauna are released as early as possible

Distribution of entrained hydrocarbons

- Only apply surface dispersants within the Zone of Application and on BAOAC 4 and 5

Toxicity of dispersants

- OSCA approved dispersants prioritised for surface and subsea use

Presence of personnel on the shoreline

- Oversight by trained personnel who are aware of the risks
- Trained unit leader's brief personnel of the risks prior to operations
- Shoreline access route (foot, car, vessel and helicopter) with the least environmental impact identified will be selected

- Vehicular access will be restricted on dunes, turtle nesting beaches and in mangroves

Waste generation

- Zoning of response locations to prevent secondary contamination.
- Limiting vegetation removal to only that vegetation that has been moderately or heavily oiled.
- Minimising the mixing of clean and oiled sediment and shoreline substrates.

Additional stress or injury caused to wildlife

- Operations conducted with advice from the DBCA Oiled Wildlife Advisor and in accordance with the processes and methodologies described in the WA OWRP and the relevant regional plan

APPENDIX C: SUMMARY OF STAKEHOLDER FEEDBACK AND WOODSIDE'S RESPONSE

Relevant Stakeholder feedback for the Petroleum Activities Program

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
Department of Industry, Innovation and Science	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
Department of Primary Industries and Regional Development	**Woodside email sent:** 18 May 2018 Email with fact sheet and State Fisheries map.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
Australian Hydrographic Service (AHS)	**Woodside email sent:** 21 May 2018 Email with fact sheet.	**Date:** 21 May 2018 **Feedback summary:** Automatic response acknowledging receipt of email.	The stakeholder raised no claims or objections.	No further action is required.
Department of Mines, Industry Regulation and Safety (DMIRS)	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Date:** 31 May 2018 **Feedback summary:** DMIRS reviewed the information provided and acknowledged Woodside's planned activities. No further information was requested but they requested that the activity commencement and cessation notifications be provided.	The stakeholder raised no claims or objections.	Woodside to provide activity commencement and cessation notifications to petroleum.environment@dmirs.wa.gov.au.
Australian Maritime Safety Authority (AMSA) (maritime safety)	**Woodside email sent:** 22 May 2018 Email with fact sheet and Shipping Density Map	**Date:** 22 May 2018 **Feedback summary:** AMSA acknowledged the notification and provided a vessel traffic plot detailing activity through the proposed Achernar well site and the	**Date:** 22 May 2018 Woodside responded by providing estimated drill time lengths and confirmed AMSA's JRCC and the Australian Hydrographic Office will be notified prior to	Woodside to notify AMSA JRCC and the Australian Hydrographic Office of upcoming drilling operations prior to commencement, and re-consult with AMSA when drilling operations have

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
		WA-28-P permit area. AMSA requested the length of drilling times for the proposed wells and requested the drilling vessel and MODU notify AMSA's Joint Rescue Coordination Centre (JRCC) 24-48 hours prior to operations commencing and provide cessation timings. AMSA also advised that the Australian Hydrographic must be notified of operations commencing no less than four (4) weeks prior to commencement.	operations commencing alongside all activity/vessel details requested by AMSA.	commenced and ceased **(**Error! Reference source not found. of EP**)**.
		Date: 22 May 2018 **Feedback summary:** AMSA acknowledged the notification and thanked Woodside for providing the estimated drill length timings.		
Department of Defence	**Woodside email sent:** 18 May 2018 Email with fact sheet and Defence map	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
Department of Transport	**Woodside email sent:** 18 May 2018 Email with fact sheet	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
	Woodside email sent: 3 August 2018	**Date:** 3 September 2018 **Feedback summary:** The	**Date:** 20 July 2018 Woodside responded by	Woodside is awaiting feedback from DoT on the Oil

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
	Email with Oil Pollution First Strike Plan	Oil Pollution First Strike Plan was not attached.	providing the Oil Pollution First Strike Plan. **Date:** 7 September 2018 Woodside requested a date that feedback could be provided by. **Date:** 18 September 2018 Woodside requested a date that feedback could be provided by.	Pollution First Strike Plan.
Australian Maritime Safety Authority (Marine Pollution)	**Woodside email sent:** 18 May 2018 Email with fact sheet	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
Commonwealth Fisheries Association	**Woodside email sent:** 18 May 2018 Email with fact sheet and Commonwealth fisheries map	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required.
Western Australian Fishing Industry Council (WAFIC)	**Woodside email sent:** 22 June 2018 Email with fact sheet and State fisheries map	**Date:** 22 June 2018 **Feedback summary:** WAFIC advised that the State fisheries map provided by Woodside was not appropriate for consultation purposes due to its general nature. WAFIC advised Onslow Prawn, Marine Aquarium Fish, Specimen Shell, and Area 2 Mackerel fisheries have licence areas overlapping the WA-28-P	**Date:** 20 July 2018 Woodside responded by confirming the following stakeholders were consulted: • Pearl Oyster • Gascoyne Demersal Scalefish • West Coast Deep Sea Crustacean • Pilbara Fish Trawl • Pilbara Trap • Onslow Prawn	No further action is required.

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
		permit, however are not active in the area or at these depths and thus should not be considered relevant stakeholders. WAFIC also requested a list of stakeholders who were consulted for this EP.	• Mackerel Fishery • South West Coast Salmon • Abalone • Marine Aquarium Fish • Specimen Shell Woodside advised that a conservative consultation approach was undertaken ensure all fisheries with licence areas overlapping the permit area were notified. Woodside noted WAFIC's advice, and ensured a more in-depth assessment of relevant stakeholders will be conducted in the future. Woodside also sought advice on how best to identify specific licence areas within wider fisheries to best tailor targeted consultation. Woodside prepared an alternative map encompassing WAFIC's feedback and forwarded to WAFIC for advice on its suitability for future EP consultation activities.	
			Date: 15 August 2018 **Feedback summary:** Woodside followed up its response to understand if WAFIC had any further	

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
			feedback to provide.	
		Date: 15 August 2018 **Feedback summary:** WAFIC responded to Woodside's response, and reemphasised that it was important to only consult with relevant fisheries. WAFIC were comfortable with the new map approach Woodside developed, however to consider including zones within each fishery map.	**Date:** 28 August 2018 **Feedback summary:** Woodside acknowledged WAFIC's feedback and advised that the new mapping approach will be implemented for future EP consultations.	
Western Australian fisheries: • Pearl Oyster • Gascoyne Demersal Scalefish • West Coast Deep Sea Crustacean • Pilbara Fish Trawl • Pilbara Trap • Onslow Prawn • Mackerel Fishery • South West Coast Salmon • Abalone • Marine Aquarium Fish • Specimen Shell	**Woodside letter sent:** 15 May 2018 Letter with fact sheet and State fisheries map	**Date:** 25 May 2018 **Feedback summary:** The West Coast Deep Sea Crustacean Managed Fishery advised Woodside that they are currently fishing south and outside of the WA-28-P permit area. The fishery advised that they wish to be consulted on relevant current and future Woodside activities, due to the depths they operate and the potential risk of equipment loss due to snagging. The fishery provided an alternate email for all future correspondence.	**Date:** 28 May 2018 **Feedback summary:** Woodside acknowledged the feedback and advised that they will continue to update on relevant current and future operations, and consult using the alternate email provided.	Update Woodside contact list to include new contact details (email).

Feedback from Interested Stakeholders on the Petroleum Activities Program

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
Pearl Producers Association	**Woodside email sent:** 18 May 2018 Email with fact sheet and State fisheries map.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Department of Biodiversity, Conservation and Attractions	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Australian Fishing Management Authority	**Woodside email sent:** 18 May 2018 Email with fact sheet and Commonwealth fisheries map.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Australian Customs Service – Border Protection Command	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Recfishwest	**Woodside email sent:** 18 May 2018 Email with fact sheet and State fisheries map.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
World Wildlife Foundation	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Australian Conservation Foundation	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Wilderness Society	**Woodside email sent:** 18 May 2018	**Feedback summary:** No response at the time of	The stakeholder raised no claims or objections.	No further action is required

Organisation	Method	Stakeholder Feedback	Woodside Assessment	Further Action
	Email with fact sheet.	submission.		
International Fund for Animal Welfare	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Australian Petroleum Production and Exploration Association (APPEA)	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required
Australian Marine Oil Spill Centre (AMOSC)	**Woodside email sent:** 18 May 2018 Email with fact sheet.	**Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections.	No further action is required