Ngujima-Yin (NY)Floating Production Storage and Offloading Facility Operations Environment Plan Summary

Production Division

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Revision 0

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1. INTRODUCTION

Woodside Energy Limited (Woodside), as Titleholder, under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (referred to as the Environment Regulations), prepared an Environment Plan (EP) for the operation of the Ngujima-Yin (NY) Floating Production Storage and Offloading (FPSO) facility, hereafter referred to as the Petroleum Activities Program. The NY Operations EP was approved by National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) on the 12 December 2018.

This EP Summary has been prepared to meet the requirements of Regulations 11(3) and 11(4) under the Environment Regulations, as administered by NOPSEMA. This document summarises the NY FPSO Operations Environment Plan, accepted by NOPSEMA under Regulation 10A of the Environment Regulations.

1.1 Defining the Activity

The Petroleum Activities Program constitutes a petroleum activity, as defined in Regulation 4 of the Environment Regulations. As such, an EP is required.

2. LOCATION OF THE ACTIVITY

The NY FPSO and subsea infrastructure are located in Commonwealth waters in Production Licence Areas WA-28-L and WA-59-L. The Greater Enfield rigid production flowline will operate under pipeline licence WA-28-L once installed. The NY FPSO is located approximately 43 kilometres (km) north of the North West Cape of Western Australia (**Figure 2-1**).

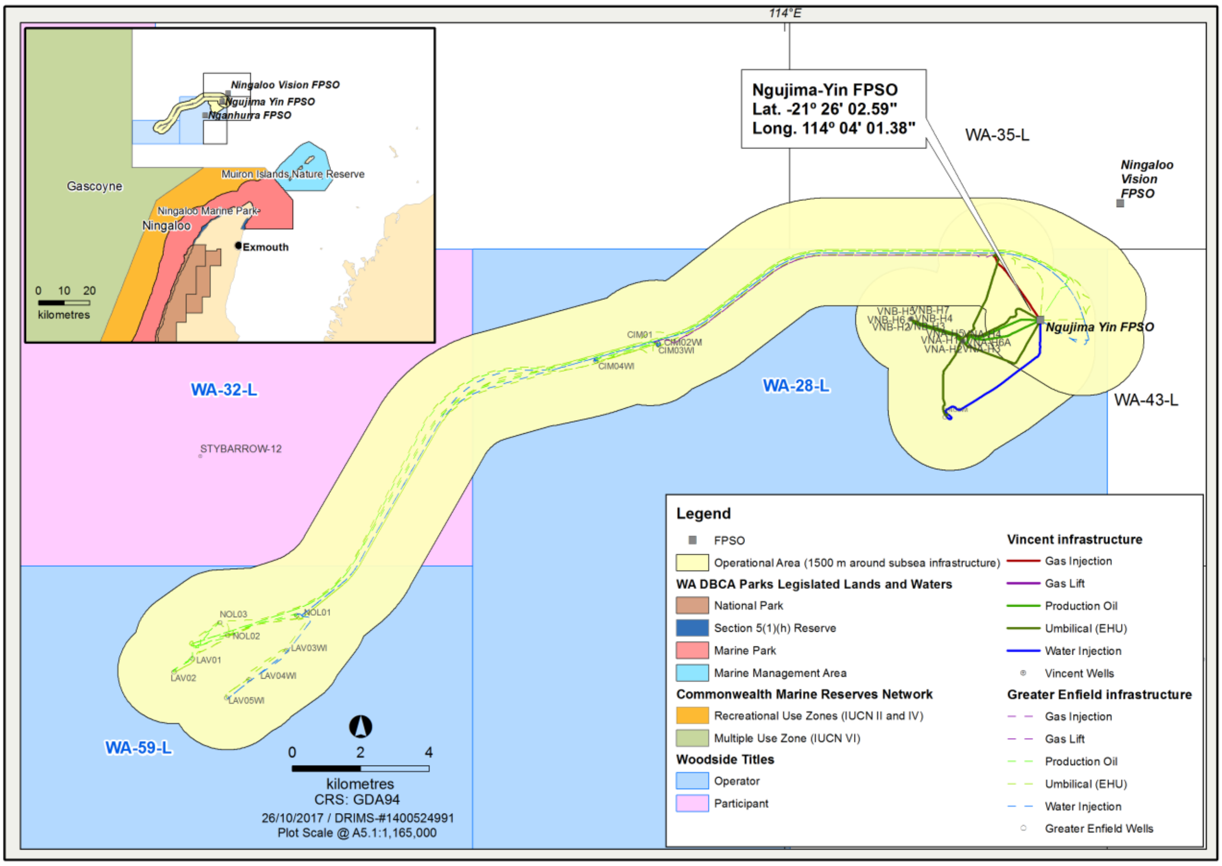

Figure 2-1: Location of the Petroleum Activities Program

The coordinates and permit areas of the NY FPSO and associated infrastructure are presented in Table 2-1**.** Locations for Greater Enfield are planned only, and subject to final as laid surveys to determine their final position.

Table 2-1: Approximate Location Detail for the Petroleum Activities Program

Activity	Water Depth (Approx. m LAT)	Latitude	Longitude	Production Licence
NY FPSO	~340	21° 26' 02.661" S	114° 04' 01.325" E	WA-28-L
GED Pipeline	~342 to 844	N/A		WA-28-PL
Vincent				
Gas injection well VNC-GI1	~370	21° 25' 01.940"S	114° 03' 16.94"E	WA-28-L
Water injection well VNC-WI2	~346	21° 27' 33.210"S	114° 02' 32.529"E	WA-28-L

Activity	Water Depth (Approx. m LAT)	Latitude	Longitude	Production Licence
Water injection well VNC-WI3	~346	21° 27' 32.400"S	114° 02' 34.800"E	WA-28-L
Well VNA-H1	~363	21° 26' 23.310"S	114° 02' 48.390"E	WA-28-L
Well VNA-H2	~364	21° 26' 22.630"S	114° 02' 47.670"E	WA-28-L
Well VNA-H3	~364	21° 26' 22.160"S	114° 02' 48.120"E	WA-28-L
Well VNA-H4	~364	21° 26' 22.850"S	114° 02' 48.850"E	WA-28-L
Well VNA-H5	~363	21° 26' 22.233"S	114° 02' 49.347"E	WA-28-L
Well VNA-H6	~363	21° 26' 23.670"S	114° 02' 49.200"E	WA-28-L
Well VNB-H1	~392	21° 26' 02.290"S	114° 01' 59.070"E	WA-28-L
Well VNB-H2	~392	21° 26' 01.760"S	114° 01' 58.259"E	WA-28-L
Well VNB-H3	~392	21° 26' 01.150"S	114° 01' 58.590"E	WA-28-L
Well VNB-H4	~392	21° 26' 01.660"S	114° 01' 59.410"E	WA-28-L
Well VNB-H5	~392	21° 26' 01.215"S	114° 02' 00.073"E	WA-28-L
Well VNB-H6	~393	21° 26' 02.244"S	114° 01' 57.675"E	WA-28-L
Well VNB-H7	~392	21° 26' 00.406"S	114° 01' 59.728"E	WA-28-L
Greater Enfield				
Well LAV01	~845	21° 31' 23"S	113° 50' 40"E	WA-59-L
Well LAV02	~849	21° 31' 36"S	113° 50' 22"E	WA-59-L
Water injection well LAV03WI	~805	21° 31' 15"S	113° 52' 09"E	WA-59-L
Water injection well LAV04WI	~804	21° 31' 43"S	113° 51' 33"E	WA-59-L
Water injection well LAV05WI	~820	21° 32' 00"S	113° 51' 12"E	WA-59-L
Well NOL01	~804	21° 30' 42"S	113° 52' 19"E	WA-59-L
Well NOL02	~824	21° 31' 01"S	113° 51' 13"E	WA-59-L
Well NOL03	~826	21° 30' 49"S	113° 51' 06"E	WA-59-L
Well CIM01	~530	21° 26' 23"S	113° 57' 56"E	WA-28-L
16” pipeline In Line Tee	~530	21° 26' 22"S	113° 57' 54"E	WA-28-L
Water injection well CIM02WI	~526	21° 26' 25"S	113° 58' 00"E	WA-28-L
Water injection well CIM03WI	~526	21° 26' 26"S	113° 58' 01"E	WA-28-L
Water injection well CIM04WI	~562	21° 26' 41"S	113° 57' 01"E	WA-28-L

3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

Woodside is the operator of the NY FPSO and associated infrastructure (**Figure 2-1**) and holds 60% equity in the NY facility; equity partner Mitsui E&P Australia Pty Ltd holds 40% equity. The NY FPSO is a conversion of the Ellen Maersk, a very large crude carrier from the Maersk fleet (type E). It was constructed in 2000 then converted to an FPSO facility in Singapore during 2007-2008. It has a double hull and a displacement of 308,490 deadweight tonnage (dwt).

The NY FPSO topside processing facilities include oil, water and gas separation systems, water injection and gas compression, plus injection equipment. The topsides are designed to process 120,000 barrels per day (bbl/d) oil, 230,000 bbl/d water, 250,000 bbl/d total liquids and up to 55 million standard cubic feet per day (MMscfd) of free gas production.

The NY FPSO produces crude oil from the Vincent reservoir and, with the completion of the Greater Enfield (GE) Tieback Project, will also produce crude oil from the Norton-over-Laverda Reservoir, Laverda Reservoir and Cimatti fields. Under normal operations, surplus gas and produced water (PW) is disposed by reinjection back into the reservoir. Gas reinjection also provides artificial lift for the Cimatti (CIM) field. For the GE wells, water produced by topsides via a dedicated treatment system is reinjected via dedicated water injection wells for pressure support. After processing, the stabilised crude oil is offloaded to trading tankers for export.

The infrastructure covered by this EP includes the:

- NY FPSO (while within the Operational Area);
- Submerged Turret Production (STP) buoy and associated mooring system including chains and anchors;
- Subsea infrastructure tied back to the NY FPSO including the GE Tieback project; and
- Supporting activities associated with the activities defined above (vessel operations and helicopter transfers).

3.2 Operational Area

The Operational Area defines the spatial boundary of the Petroleum Activities Program. The area includes (**Figure 2-1**):

- The NY FPSO and the area within a 500 meter (m) Petroleum Safety Zone[1] around the facility, and an area extending out to 1500 m to allow for offtake activities; and
- The NY FPSO subsea infrastructure, including wells, flowlines and associated infrastructure, and an area within 1500 m around the infrastructure.

Vessel related activities within the Operational Area will comply with the EP. Vessels supporting the NY facility when outside the Operational Area will adhere to all applicable maritime regulations and other requirements.

3.3 Timing of the Activities

The NY facility commenced production in 2008. The facility operates 24 hours a day, 365 days a year. Supporting operations, such as maintenance activities, take place as required.

[1] The Petroleum Safety Zone associated with the NY FPSO was gazetted on 11 October 2017 (as published in Gazettal Notice A575120), and is valid until revoked.

The GE Tieback Project (Drilling and Subsea Installation) commenced in January 2018, with these activities being the scope of a separate EP (*Greater Enfield Tieback Environment Plan).* Commissioning of wells and infrastructure installed during the GE Tieback Project is included in the scope of this EP and is scheduled in mid 2019.

Tie-back opportunities are continuously being reviewed for Woodside's offshore facilities, which have the potential to extend the life of the field. Any future decommissioning plans will be the subject of a separate EP.

3.4 Facility Layout and Description

This section provides an overview of the NY FPSO and associated infrastructure, as relevant to consideration of the environmental risks and impacts of the Petroleum Activities Program.

3.4.1 Topsides

The NY FPSO has an overall length of 332 m and breadth of 58 m. The topsides comprise 11 pre-assembled modules elevated above the NY FPSO deck, with a plated lower deck and grated upper decks. Each module has its own primary structure, equipment, associated piping, valves and instrumentation.

A production laboratory, stores and electrical and mechanical workshops are located aft of the main laydown area on the port side.

Modifications of the NY FPSO will be undertaken as part of the GE Tieback Project and primarily relate to providing new functionality. These modifications will be undertaken in a shipyard when the NY FPSO is off station. As such, their construction and installation do not form part of the scope of this EP. Once the NY FPSO returns to the field, the new functionality forms part of the standard processes of the FPSO. Environmental aspects associated with these modifications have been considered within the scope of this EP.

3.4.2 Reservoirs and Well Configuration

Each well is completed with a subsea xmas tree incorporating wellhead controls for opening and closing the valves to isolate and regulate flow. The primary down-hole safety system is surface controlled subsea safety valves on each well, which are installed in the production tubing at approximately 100 m below the seabed.

The facility Integrated Control and Safety System operates all subsea xmas tree and manifold valve functions. It also monitors all xmas tree mounted instrumentation and the multi-phase flow meter located at each manifold.

Vincent Reservoir

- Oil from the Vincent reservoir is produced through 13 subsea production process PW wells via two production manifolds (drill centre A (DCA) and drill centre B) connected to the NY FPSO.
- Two water reinjection wells are daisy-chained on dedicated flexible flowline from the NY FPSO. An umbilical runs between the water reinjection wells and the DCA manifold.
- The single gas reinjection well also has a dedicated flexible flowline from the NY FPSO, and an umbilical runs between the well and the DCA manifold.

Laverda Canyon (LAV) Reservoir

- Fluids from the LAV reservoir are produced from two subsea production wells and pumped to the NY FPSO via the rigid production flowline.
- Three water reinjection wells are daisy chained via flexible flowlines with injection water supplied from the NY FPSO to the rigid injection flowline.

Norton-over-Laverda (NOL) Reservoir

- Fluids from the NOL reservoir are produced from three subsea production wells and pumped to the NY FPSO via the rigid production flowline (also used for fluids from the LAV and CIM reservoirs). No water is injected into the NOL reservoir.

Cimatti (CIM) Reservoir

- Fluids from the CIM reservoir are produced from a single subsea production well and transported to the NY FPSO via a tie-in to the rigid production flowline (also used for fluids from the LAV and NOL reservoirs).
- Three water injection wells supplied by the rigid water injection flowline are used to inject water into the CIM reservoir.

3.4.3 Flowline and Riser System

Vincent

For the Vincent production system, there are two 10’’ flowlines extending from the wells to the risers connected to the NY FPSO. The total riser capacity is two 10’’ production risers, one 10’’ water disposal riser and one 6’’ gas injection riser.

Greater Enfield (GE)

The GE system consists of a ~31 km, 16” outer diameter (OD) wet insulated carbon steel rigid production flowline and associated 14” flexible and 10” flexible production risers. The production flowline runs between the multiphase pumping (MPP) station (which provides pressure boost) to the riser base and riser connecting to the FPSO STP buoy.

A ~31.6 km, 10” OD carbon steel rigid water injection flowline and an 8” inner diameter (ID) flexible riser provides water injection for pressure support. The system also includes:

- A six-inch ID flexible gas lift flowline for artificial lift of CIM well;
- Eight-inch ID flexible production flowlines connecting production wells to the MPP Station (LAV and NOL), and six-inch flexible from CIM well to the rigid flowline inline tee;
- Eight-inch flexible flowlines for water injection; and
- Eight-inch ID flexible flowlines to facilitate flowback of water injection wells via the production system

3.4.4 Subsea Infrastructure

The main components of subsea infrastructure include wells, wellheads, manifolds, and umbilicals.

The NY facility subsea infrastructure, incorporating both Vincent and GE consists of the following components:

- Trees/wells;
- Manifolds;

- Rigid spools;
- Flying leads;
- Power and control umbilicals;
- Risers;
- Umbilical termination assembly;
- Turret and mooring systems;
- MPPs;
- Subsea pig launch and receive facility; and
- Subsea support structures (e.g. parking stands, anti-walking structures).

The subsea system is typically controlled from the NY FPSO though the following components:

- Umbilicals which provide hydraulic services, electrical power and control services, and chemical injection services required;
- Valves which control subsea operations and processes;
- Chokes which control pressure and flow rates from the production and water injection wells; and
- Subsea Control Modules (SCM) which are sealed and pressure compensated electro-hydraulic units (typically found on manifold and/or xmas trees) and link the surface and subsea controls.

A number of subsea valves may also be overridden manually from a Remote Operated Vehicle (ROV).

3.4.5 Submerged Turret Production and Mooring System

The NY FPSO is moored to the east of the Vincent field centre. The STP and mooring system enables the NY FPSO to freely weathervane, while allowing production from the reservoir through the swivel stack. In weather conditions which may exceed system design limits, or for planned remedial or modification works, the NY FPSO can be disconnected from the risers, umbilicals and mooring system and sail-away from the field under its own power.

The mooring system comprises three groups of three mooring lines. Each mooring line is composed of chain and wire segments, and a mooring line buoyancy element is located between the upper and lower wire rope segments. Clump weights are attached to the chain segment of the three most loaded lines to reduce vessel offset and line and anchor tension during extreme weather.

Reservoir production fluids are transferred from the risers to the topsides processing system via the swivel stack fluid transfer system. This also allows PW, reservoir injection water and gas from the topsides to be reinjected into reservoirs. The swivel stack also provides electrical power hydraulics and chemicals to the subsea infrastructure.

The NY FPSO's disconnect-able STP system comprises the:

- STP buoy, which provides the interface between the NY FPSO hull and the mooring system and risers. The STP buoy comprises a buoyancy cone and turret, through which the risers and umbilicals pass. The STP buoy is moored to the seabed by mooring chains and anchors which are fixed to the lower turret structure, and connected to the hull by the locking mechanisms in the STP compartment.
- STP compartment, which is cylindrical and built into the NY FPSO's former cargo tank No. 1 centre. The compartment houses the STP equipment, including the swivel system, locking mechanisms and chemical distribution panels. The lower part of the STP compartment is the 'mating cone module', and forms the interface between the hull and the outer part of the STP buoy.

When disconnected from the NY FPSO, the STP buoy floats at approximately 28 m below the sea surface.

Disconnection of FPSO from the STP Mooring

The connection and disconnection of the NY FPSO from the STP buoy is a controlled activity, conducted in accordance with specific procedures. To prepare for disconnection, production is shut down and the topsides, risers and flowlines are depressurised via the flare system. The risers are depressurised to a nominated safe pressure before closing the riser Emergency Shutdown Valves (ESDVs) and isolation valves. The piping within the STP compartment and swivel are drained, flushed and purged before disconnection.

The risers and umbilicals are disconnected from the swivel, and the swivel stack is moved on the swivel trolley. This is to allow free access to the top of the buoy and a clear route for the pull-in rope connection between the buoy and the winch. The STP buoy is then released and lowered from the hull.

To complete a disconnection, the STP compartment is flooded to equalise water level prior to disconnection. Individual hydraulically-operated locking mechanisms installed around the circumference of the upper mating ring are then released, and the FPSO sails away.

Reconnection of FPSO from the STP Mooring

The first stage of the reconnection procedure involves pulling in the STP buoy using the STP winch. Cameras in the STP compartment and a satellite navigation positioning system are then used to monitor position during the pull-in. Once the STP buoy is inside the hull, the locking mechanisms within the mating cone module are engaged. Positive engagement is verified on the control system. The mating cone seal is activated from the STP utility container. The STP compartment is then drained using the NY FPSO ballast pumps and STP compartment drains system.

The blinds are then reinstated on the STP compartment filling valves and swivel, and the pipework and umbilicals are reconnected (in reverse to the disconnection procedure).

3.5 Operational Details

This section provides a description of the main operations associated with the facility. It includes key elements in relation to interaction between the activity and the environment.

3.5.1 Manning and Modes of Operation

The total overnight Personnel on Board (PoB) capacity for the NY FPSO is 80 people. The Central Control Room (CCR) is manned 24 hours per day. Activities which affect manning levels are:

- Crew change;
- Engineering projects;
- Campaign maintenance;
- Inspections/audits; and
- Planned facility shutdowns.

The main NY facility modes of operation are discussed in more detail below.

Production and Maintenance

Production and Maintenance covers hydrocarbon receipt, processing, storage for offloading, offloading to export tankers, and supporting operations. Inspection, maintenance and repairs are undertaken concurrently to maintain production within the NY facility design constraints.

Production and Major Projects

Major projects involve refurbishment, modification or major maintenance on the facility. It is possible to disconnect the FPSO and sail to a shipyard to complete major maintenance or project work off-station.

FPSO Marine (Disconnected) Mode

The NY FPSO has retained its functionality as a self-propelled seagoing vessel. The existing ship's auxiliary machinery, power generation, propulsion and steering systems are retained and maintained during FPSO service. The ship's main engine is a diesel engine with an output of 27,160 kilowatt (kW) and is required when the NY FPSO is off-station.

Once disconnected from the STP buoy, the FPSO must comply with all applicable maritime regulations. The service speed of the NY FPSO (disconnected) is approximately 15.7 knots at a design draught of 20.95 m. The NY FPSO maintains marine classification as a seagoing vessel and Woodside is responsible for ensuring it meets the Flag State Authority (Australia under Australian Maritime Safety Authority (AMSA)) and classification society requirements. The International Maritime Organization (IMO) Safety of Life at Sea (SOLAS) Convention is used as an umbrella reference guide to maritime certification requirements, and is adopted by AMSA. Lloyd's Register classification rules for floating installations at a fixed location apply. Their application is verified by the classification society during periodic surveys.

The NY FPSO is maintained in a condition ready to disconnect at all times, and has the required complement of marine personnel to operate as a seagoing vessel. Criteria that need to be considered when disconnecting from the mooring because of adverse weather includes the predicted wind speed, currents and wave heights, in comparison to the associated vessel operational limits and anticipated pitch, roll, heave and draft of the vessel.

If the pneumatic control system fails, the main engine can be controlled from an emergency control stand located at the engine room. The steering gear is also provided with an emergency control position.

3.5.2 Process Description

The NY facility receives well fluids (gas, condensate and associated PW) from the production wells for topside processing including:

- Separation of gas, crude oil and water;
- Gas compression and disposal; and
- PW treatment and injection / disposal.

The NY FPSO directly exports processed, stabilised crude oil via offloading to offtake tankers. The first stage of processing is separation of the well fluids in the two high pressure (HP) separators (A and B). The fluids are then further separated in the low pressure (LP) separator/degasser then the electrostatic coalescer to achieve crude oil export specifications. The crude is then cooled and transferred into the NY FPSO oil storage tanks for export.

Gas Compression Systems

The 'flash gas' (gas released in the separation process) is routed to the gas compression systems for use as fuel gas and reinjection into the reservoir during normal operations, or disposed to the flare system during process upsets.

Flash gas from the LP separator/degasser is routed directly to the LP gas compression system, while gas from the HP separators is routed to the HP gas compression system for use as fuel gas or reinjection into the reservoir.

Flare Systems

The NY FPSO has two flare systems, the HP Flare and the LP Flare. The main purposes of the flare systems are to safely discharge gas streams during an emergency depressurisation, or to use when the compression systems are unavailable. However, there are some process streams which continuously pass gas to the flare, such as stripping gas used in the glycol regeneration process. Other streams intermittently flow to the flare, such as during process upsets, maintenance activities, and when vessels are depressurised.

All HP and LP flare pipework is continuously purged with nitrogen for fuel gas, to prevent the possibility of an explosive mixture developing within the system.

The flow of gas through each of the HP and LP flare networks is measured using separate ultrasonic flow meters.

Normal Operations

During normal operations, the majority of gas produced from the production process is reinjected into the reservoir. A relatively small quantity of gas must be continuously flared.

The continuous flows to the LP flare are the:

- flare pilot;
- LP flare header and storage tank purges; and
- glycol regeneration process, including still column overheads.

The continuous flows to the HP flare are:

- flare pilot; and
- HP flare header purges.

Leakage past pressure safety valves, pressure control valves, manual valves and blowdown valves may also result in a continuous flow; however, this is usually negligible.

Estimated Flare Volumes

Annual flare targets are set based on operational activities planned for the year. This target is used to assess facility flare performance. In general, maintenance and upgrade works contribute to reduced flaring through increased reliability. This is because the flaring quantities during unplanned events are significantly higher than flaring quantities during normal operation hence the focus on optimisation of system reliability. Total upper estimate of flaring from normal operations, intermittent process upsets and activities and unplanned events is approximately 31,000 tonnes per annum.

3.5.3 Produced Water Treatment and Disposal

PW is brought to the surface from the reservoir and is separated from the hydrocarbon components during the production process. Separation of PW from reservoir fluids is not 100% effective; separated water often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (aliphatic and aromatic hydrocarbons, organic acids and phenols) and inorganic compounds (e.g. soluble inorganic chemicals, dissolved metals).

The process for oil and water separation and disposal of PW are outlined below.

Oil and Water Separation

PW treatment begins in one of two HP separators, where the combination of chemical injection, residence time and temperature promotes the separation of water from oil. The water separates to the bottom of each HP Separator, then enters a coagulation vessel and through to a hydrocyclone unit. The rejected oil from the hydrocyclone is returned to the process.

From the hydrocyclone, the PW is directed through one of the PW filters to remove particulates. The filtered water continues on through to the PW degasser. The degasser is fitted with an internal oil skimming facility to remove residual oil build-up in the degasser vessel.

Produced Water Disposal

After leaving the degasser, the primary disposal method is through water injection pumps to the water injection wells within the reservoir area.

The primary disposal method may not be used in circumstances such as when the reinjection system is unavailable, oil-in-water re-injection criteria cannot be achieved, or there has been a trip of the water injection pumps. In this situation, PW may be directed to a temporary holding tank.

PW directed to the holding tank can be disposed of by pumping the liquid back into the PW process. This is done using closed drain drum pumps to direct the PW into the HP separators. During routine operations PW is reinjected as described above and therefore is not described further in this EP. Discharge of PW to the marine environment during routine operations is not permitted in this EP.

Non routine discharge of PW and residual chemicals may be required as described below.

Temporary Water Treatment Skid (the Cetco)

During non-routine discharge of PW overboard an additional temporary water treatment package (the Cetco) will be used to treat the water before it is discharged. The Cetco is temporary equipment only and will be in place throughout GE Start-up and commissioning until completion of Ready For Start-Up (RFSU) 5.

The Cetco water treatment package comprises two solids filtration trains (2 x 100%) ~20 microns (µm) filters to remove solids and two coalescer vessels (2 x 100%) to remove oil and meet overboard discharge quality requirements (30 mg/L 24 hr rolling average).

Water is discharged to the ocean via a caisson located a minimum of 3 m below the surface.

Cetco Oil and Water Separation

Oil removal on the Cetco is conducted by two coalescer vessels which removes oil by mechanical separation. To monitor oil in water (OIW) separation in the coalescer and discharge, the Cetco skid will be fitted with an online OIW analyser. This OIW analyser continuously monitors OIW levels, however it is not connected to the FPSO digital control system therefore manual readings are taken to monitor OIW concentrations. OIW levels are logged electronically by the analyser to form a historical record once downloaded.

Downstream of the OIW analyser is a manually operated valve that prevents discharge of off specification water to the ocean. When this valve is closed, all water leaving the Cetco is recycled into a designated holding tank for further processing.

Cetco solids removal

The 20 µm filters upstream of the coalescer are designed to reduce solids, with a typical minimum performance of 80% - 90% removal being achieved.

Performance of the filters is monitored by observing pressure drop across the filters. If the pressure drop is greater than 2 bar, the clean stand-by filter is brought online while the fouled filter replaced.

3.5.4 Drainage Systems

The NY facility can be separated into two drain systems: the process drain systems and the marine drains.

The process drains systems collect hydrocarbon-based and other liquid wastes (rain and wash water, etc.) from all process areas across the facility via the following segregated sub-systems: hazardous drains; non-hazardous open drains; and closed drains.

The open process drains system is required for collecting water and hydrocarbons which are at atmospheric pressure (e.g. deck water). The process hazardous open drains system is designed to remove and collect any oily water from hazardous areas on the NY FPSO, including wash down water, some maintenance activities discharges and spillage of liquids on process decks, equipment drip trays or bunded areas. The hazardous open drain contents are directed to the hazardous open drains tank. The contents of the hazardous open drains tank are discharged to the slops tank.

The open process drains system is configured such that extreme rainfall or fire water deluge on the topsides modules is discharged directly overboard. The system is designed to route the initial run off to the hazardous open drain tank to collect any hydrocarbons which may have accumulated in the process equipment bunds, and operates only in the case of excessive water flows.

The marine drains are located throughout the machinery spaces on the main deck and in the accommodation. The marine drains' contents are eventually discharged to the slops tanks.

The closed drains system is used for draining volatile hydrocarbon residue from all enclosed process equipment. The closed drains system is combined with the LP flare system and consists of an LP flare knockout/closed drain drum and transfer pumps. The hydrocarbon liquid drained from the process equipment is drained by vessel pressure and gravity to the LP flare/closed drains drum. The closed drains drum liquids are discharged from the closed drain transfer pumps to the LP separator, where it is returned to the separation process.

The STP closed drain system is designed to collect hydrocarbon residue resulting from flushing and draining prior to disconnection. The system also supports the swivel barrier leakage tanks, which collect the fluid residue from the turret. The residue from the collection and leakage tanks is automatically discharged to the closed drains header via drain pumps. After a reconnection, the STP compartment is drained of seawater using the ship's ballast pumps. Drain sumps and pumps are used to assist with final dewatering of the STP compartment, and act as the STP compartment open drain recovery system.

Machinery Space Bilges

The NY FPSO machinery space includes the ship's main engine and other auxiliary machinery. Oily water mixtures and hydrocarbon residue generated in this area are drained to the machinery space bilge tank. When required, the contents of the bilge tank are pumped to the NY FPSO slops tank.

FPSO Slops Tank Management

In addition to the drainage processes discussed above, the NY FPSO slops tank may receive other less frequent sources of drainage water, primarily from marine operational activities. This includes activities such as Customised Water Flood (CWF) clean-in-place, cargo tank de-bottoming, cargo tank stagger test water (for tank integrity testing), water washing of cargo tanks, and heavy weather ballasting where the cargo tanks may need to be used for ballast.

Slops are re-injected into the reservoir during normal operations.

Deck Drain Overflow System

The overflow system is designed to collect fire water deluge demand for deck modules, or in some cases extreme rainfall, and discharge the accumulated water directly overboard or to the marine collection system (break tank). To collect the overflow from the modules, decks are bunded and provided with drain gullies, with an overboard drain connection.

From the main deck, the liquid is collected on the main deck area then routed via the overboard header(s) to the sea.

3.5.5 Cargo Tanks

The NY FPSO has 14 cargo tanks designed to receive cooled stabilised crude oil from the topsides process system. The individual storage tanks capacity range in size, with a total operational storage capacity of 1.2 million barrels (bbls).

The cargo pumps transfer the crude to offtake tankers and are located forward of the engine room, in a dedicated pump room, driven by a three-stage impulse steam turbine. The pumps are each equipped with an automatic unloading system. The export rate with a single pump is 530,000 bbls (84,270 cubic meters (m^3)) per day (refer to Offloading System and Offtake Tanker Mooring below for further detail).

The cargo oil system is capable of inter tank transfer of crude and offloading simultaneously with either loading, crude oil washing or internal cargo transfer, as well as full slop tank functions dealing with oily water mixtures (sourced from either topsides or cargo operations).

Cargo loading and discharge is managed from the CCR where the following is controlled and monitored:

- cargo planning;
- cargo pumps and valves;
- cargo tank levels, pressures and temperatures;
- inert gas quality and pressure;
- gas leakage into the ballast tanks via the gas detection system; and
- tank high level overfill alarm system.

An independent overfill alarm is fitted to each cargo and slop tank, and activated when the liquid level reaches a set point (normally 98% by volume). The cargo tanks are fully inerted during all cargo handling operations, with all tanks common onto the main inert gas header. An emergency shutdown valve (ESDV) is incorporated in the rundown line from the process plant.

3.5.6 Ballast System

The NY FPSO sea water ballast system is used to counteract sheer force and bending movement stresses on the FPSO's hull, caused by the loading and offloading of crude oil in the cargo tanks. Ballasting is also required to control the trim and heel of the vessel, to ensure stability remains within the design limits.

The vessel complies with International Convention for the Prevention of Pollution from Ships (MARPOL) Protocol 73/78, with the ballast system completely segregated from the crude oil storage system. Segregated ballast is carried in the fore and aft peaks of the NY FPSO, and in five pairs of wing tanks arranged the entire length of the cargo tank area. The total capacity of the segregated ballast tanks is approximately 100,007 m^3. The ballast pumps are interconnected to permit flexibility of operation.

3.5.7 Offloading System and Offtake Tanker Mooring

The NY FPSO has a tandem offloading system, providing handling facilities to non-dedicated tankers of up to 150,000 T size, in accordance with Oil Companies International Marine Forum (OCIMF) requirements.

Before gaining Woodside's acceptance for offloading from the NY FPSO, export tankers are assessed for their performance, quality (historic performance or incidents, documentation, systems and procedures) and operational compatibility with the facility. Additional quality assurance of tankers is provided by external bodies with access to extensive databases, which ensures thorough evaluation (for example, the Shell 'SAFE-T' system). A tanker will only be accepted by Woodside for offloading if it passes the assessment. This requirement applies to each tanker offload, irrespective of the tanker flag, operator, or the date of the last visit to a Woodside terminal.

Once accepted for offloading, the tanker must comply with requirements under the NY Technical Systems Manual (TSM) – Offloading Systems which contains rules, information and operations guidelines. The manual also describes the operations and approach to the NY facility's cautionary and safety zone, and the rules that apply in each area. Approach to the facility must first be approved by the NY Offshore Installation Manager (OIM), then occurs under supervision of a Woodside Pilot in accordance with the IMO and International Maritime Pilots Association Guidelines.

Crude is offloaded to the offtake tanker via a 16" diameter 289 m long floating hose. It comprises a heavily reinforced material in sections approximately 10 m long, with flanged and bolted connections between sections. This allows each section to be independently tested and replaced if necessary. A double dry break coupling is fitted approximately 20 m from the offtake rail end of the hose, which will release at a predetermined tension. Oil spillage is minimised by closing the valves in each half of the parted dry break coupling.

Offloading operations from the NY FPSO take place as required, based on production rates. Offtakes are expected to increase to approximately every eight days following start-up of the GE tieback, and will decline in frequency as production rates drop over time. Trading tankers have an oil storage capacity of up to 120,000 m^3; a full loading operation is expected to take up to 30 hours. Initial loading rates are approximately 700 m^3/hr; however, once safety and override checks are satisfactory, the rate is increased to suit offtake tanker requirements, to a maximum loading rate of 4200 m^3/hour.

Offloading to tankers is monitored by the NY FPSO's approved Stress and Stability program, which continuously calculates the stresses in the hull based on measured liquid levels and densities within the tanks, and provides alarms if hull stresses exceed the allowable envelope.

The offtake hose is stored on a stern mounted hose reel when not in use. This reduces the likelihood of hose damage during handling or impact by vessel and subsequent hydrocarbon release.

3.5.8 Utility Systems

The NY FPSO facility has a range of utility systems to support operations including;

- Facility lighting;
- Heating Ventilation and Air Conditioning (HVAC) System;
- Nitrogen system / generation;
- Steam system;
- Seawater treatment system (seawater system and potable water)
- CWF system;
- Inert gas system;
- Power generation;
- Fuel gas system;
- Safety features and emergency systems;
- Accommodation facilities;
- Sewage and putrescible wastes;
- Sand management; and
- Diesel fuel system.

3.5.9 Lifting Operations

Lifting operations on the NY facility include:

- Lifting from support vessels;
- Lifting around the facility;
- Special lifts using the various cranes and
- Non-crane based operational lifting.

The NY FPSO is equipped with five rotating cranes, as well as numerous local handling/lifting provisions. There are also numerous dedicated laydown areas for materials, chemicals and provisions, located to optimise the lifting handling arrangement and reduce manual handling.

3.5.10 Diesel Bunkering

Low sulphur diesel is transferred to the NY FPSO in bulk supply vessels via a hose reel and bunker connection, located on the port side of the FPSO’s main deck, forward of the accommodation. The bunker hose is handled by the port aft engine room crane. Diesel oil is stored in tanks located in the hull of the NY FPSO.

The diesel is purified and held in settling and service tanks prior to distribution for use. Diesel from the settling tank is transferred via the purifiers to the diesel service tanks for use in the topsides gas turbines, generator engines and (when required) the main engine. Outlet valves from the diesel tanks are fitted with pneumatically actuated, quick-closing valves remotely operated from the ship’s fire control station.

Bunkering of diesel fuel from supply vessels into the diesel storage tanks on the NY FPSO is a controlled activity, governed by Woodside’s permit to work system.

3.5.11 Safety and Emergency Systems

A range of safety features and emergency systems have been integrated into the design and operation of the NY facility to manage safety risk. Maintenance and operation of these systems is key to ensuring safe operability of the facility.

Specific safety systems include:

- Control and detection systems;
- Process control systems;
- CCR and bridge;
- Fire and gas detection system;
- Emergency and process shutdown systems;
- Emergency relief and depressurisation systems;
- LP and HP flare systems;
- Ignition control;
- Emergency alarms and communications;
- Cargo hazard management;
- Evacuation and rescue facilities and equipment;
- Collision avoidance systems; and
- Passive and active fire protection.

Specific details of these and other safety systems can be found in the NY (Vincent) Facility safety Case (Woodside Doc No. V1000RF0005).

3.5.12 Vessels

Facility support vessels and subsea support vessels are used in support of the NY facility. Facility support vessels provide a support capacity for transferring personnel, material and equipment to and from the facility. The vessels also backload materials and segregate waste for transport back to the King Bay Supply Base in Karratha. Vessels supporting the facility may vary depending on the vessels schedules and availability.

The normally scheduled support vessel is the *Siem Thiima*, the first liquified natural gas (LNG) powered vessel. Carbon emissions of LNG are up to 25 percent lower than diesel, and 30 percent lower than heavy fuel oil. Moreover, it emits almost no sulphur or particulates.

Subsea support vessels are also used for field work such as subsea inspection, monitoring, maintenance and repair (IMR) activities. Vessels supporting offshore activities may vary depending on operational requirements, vessel schedules, capability and availability.

Typical support vessels use a Dynamic Positioning (DP) system to allow manoeuvrability and avoid anchoring when undertaking works, due to the proximity of subsea infrastructure. However, vessels are equipped with anchors which may be deployed in an emergency.

3.5.13 Helicopter Operations

Helicopters are the primary means of transporting passengers and/or urgent freight to/from the NY facility and support vessels. They are also the preferred means of evacuating personnel in an emergency.

3.6 Hydrocarbon and Chemical Inventories and Selection

3.6.1 Hydrocarbons

Process and non-process inventories of hydrocarbons used on the NY facility are topside process hydrocarbons, crude oil and diesel oil.

3.6.2 Chemical Usage

Chemicals are used on the NY facility for a variety of purposes and can be divided into two broad categories (operational and facility maintenance).

Operational Chemicals

Chemicals used may include

- Corrosion inhibitor;
- Biocide;
- Scale Inhibitor;
- Subsea Control Fluid;
- Demulsifier; and
- Glycol and hydrate inhibitors.

Maintenance Chemicals

Maintenance chemicals include chemicals which are required for general maintenance or ‘housekeeping’ activities and are critical for overall maintenance of the facility and its equipment.

These may include paints, degreasers, greases, lubricants and domestic cleaning products. They may also include chemicals required for specialty tasks, such as laboratory testing and analysis.

Environmental Consideration During Selection, Assessment and Approval of Chemicals

As part of Woodside's chemical approval process, operational chemicals required by the Petroleum Activities Program are selected and approved in accordance with the *Woodside 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 (background on the OCNS scheme provided is below), specifically:

- Where operational chemicals with an OCNS rating of Gold/Silver/E/D and no OCNS substitution or product warning are selected, or a substance is considered to pose little or no risk (PLONOR) to the environment, no further control is required. (Such chemicals do not represent a significant impact on the environment under standard use scenarios and therefore, are considered As Low As Reasonably Practicable and acceptable).
- If other OCNS rated or non-OCNS rated operational chemicals are selected, the chemical will be assessed further.
- The ALARP assessment will consider chemical toxicity, biodegradation and bioaccumulation potential, using industry standard classification criteria (Centre for Environment, Fisheries and Aquaculture Science (CEFAS) scheme criteria).
- If a product has no specific ecotoxicity, biodegradation or bioaccumulation data available, environmental data for the product will be considered further.
- 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 which 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.
- Once the further assessment/ALARP justification has been completed, concurrence from the relevant manager that the environmental risk as results of chemical use is ALARP and acceptable is obtained.

3.7 Greater Enfield Start-up and Commissioning

As described in **Section 3.4.1** modifications to the NY FPSO for the GE tie-back project will be undertaken when the FPSO is off station. Once these are completed, the NY FPSO is planned to return to the field in the first half 2019. After reconnection to the STP, a series of Vincent re-commissioning and GE commissioning activities will occur.

Well clean-up will be an intermittent activity and will be undertaken as new production wells become available. As a result, the overboarding of treated well clean-up fluids will only occur when this activity happens. It is estimated that each production well clean-up will take approximately six days to complete across five RFSU stages (i.e. two wells simultaneously in the first RFSU and four wells in individual RFSUs).

RFSU 0 is the first start-up of the existing Vincent wells after reconnection of the FPSO. It involves commissioning some new topsides infrastructure.

GE start-up will be undertaken in phases based on availability of wells. RFSU 1 involves the start-up of the majority of the GE, with RFSU 2, 3 and 4 the start-up of the NOL wells, as they are drilled.

These are spaced by one to two months. RFSU 5 involves the start-up of the remaining CIM water injection well. The completed wells are left with associated completions chemicals ready for clean-up via the FPSO before production. Well drilling, completion and injection testing (for injection wells) is covered under the accepted Greater Enfield Tieback EP. Well clean-up and start-up activities are covered under this EP.

Before the NY FPSO arrives, the new GE subsea systems from the buoy to flow bases, including the risers, umbilicals, MPP station (with MPPs installed), pigging structures, flowline terminations, production, gas lift and CWF flowlines, will have been fully connected and hydrotested, and ready for hook-up to the NY FPSO. The completion of these activities sees the systems left in a preserved state to protect the integrity of the system. Subsea system preservation activities will be undertaken under the scope of the separate Greater Enfield Tieback EP.

Before production commences, these fluids require dewatering which will be undertaken via the NY FPSO during RFSU 0 and RFSU 1. Dewatering activities are covered under this EP.

3.7.1 Dewatering and Re-commissioning of the Vincent System

Once the NY FPSO has completed all required connect/disconnect and communications tests and is RFSU 0, the Vincent subsea production system will be started up and dewatered. The Vincent subsea gas injection system does not require dewatering. It is likely that the gas injection system will be partially pressurised with nitrogen, to allow back flow of the injection gas for fuel gas to minimise the use of diesel during commissioning.

The Vincent subsea production system was flushed and left filled with preservation fluid, made up of PW treated with biocide. This biocide dosed PW will be dewatered when production from Vincent recommences. Biocide is required to be injected into the system to prevent bacterial growth, which may cause integrity issues within the pipe by producing hydrogen sulphide (H2S).

Produced water disposal during Vincent recommissioning

In the initial days of the Vincent recommissioning period, all oil and PW from the Vincent field is directed through the existing oil processing system to an off-spec holding tank. Progressively, the PW treatment system is brought online and PW from the off-spec tank is gradually re-routed to the start of the treatment process for further oil and water separation prior to re-injection once injection specifications are met.

Design for the recommissioning process was on the basis of reinjection of all PW, including preservation fluid. However during the initial recommissioning period (RFSU 0) and production ramp up, there may be delays in starting the PW injection pumps, in commissioning the temporary water treatment skid, and/or potential for process instabilities to occur. This may result in more PW being inboarded than can be stored in the off-spec holding tanks. Due to the complex nature of this re-commissioning activity, there may be a need to discharge water via the temporary water treatment skid to avoid significant delays to resumption of steady production.

The maximum worst case PW discharge is 2,592 m^3/day over a period of 20 days or approximately 50,000 m^3.

Greater Enfield production flowline dewatering

Dewatering of the GE production flowline is completed as part of starting up the first GE production well. Due to the static head of the fluids within the flowline, it will likely be necessary to partially dewater the production system with nitrogen before start-up of the first GE well (LAV02). This activity would use a nitrogen package located on topsides which would dewater flowline fluids subsea, discharging approximately half of the volume of the flow line (~1,450 m^3) to ocean via a 2” connection at the CIM in-line tee.

Preservation water not dewatered subsea will be dewatered to the NY FPSO, directed to an off-spec tank. Preservation water from the GE flowlines is not suitable for reinjection and will therefore be directed to a temporary water treatment system prior to discharge.

The 16” production flowline contains 3,500 m^3 of inhibited seawater treated with hydrosure, corrosion inhibitor, fluorescein dye and monoethylene glycol (MEG) that were added at known volumes and concentrations as part of the Greater Enfield Tieback EP. The approximate volumes and toxicity of each chemical in the inhibited seawater within the 16” production flowline are provided in Table 3 12.

The corrosion inhibitor that was added to this pipeline was only injected at the very leading edge of inhibition fluids during the final pipeline flooding, as this product is designed to form a protective film, or coating, on the interior of the pipeline. During dewatering, only trace concentrations of corrosion inhibitor would be expected to be released.

3.7.2 Greater Enfield Production Well Clean-Up

During the GE Tieback Project drilling campaign, wells were drilled, completed and suspended with either solids free fluid (brine) or a combination of brine and diesel in the well bore. This brine is typically to achieve approximately <70 nephlometric turbidity units and/or <0.05% total suspended solids. When GE wells are cleaned up, certain topside equipment (i.e. Train B water treatment system, inter-stage heater, electrostatic coalescer, crude oil cooler) must be isolated to avoid contaminating these systems with well clean-up fluids, and to minimise the impact of solids on equipment where blockage could occur. The GE production wells will be cleaned up to HP Separator B, with Vincent wells being simultaneously produced to HP Separator A. At this time, Vincent production will be ramped back to minimum stable rates, and only wells with low PW production rates will be online.

PW separated from Vincent fluids in HP Separator A will still be injected; however, some PW will be carried over from the HP separator into the LP separator (~10–15% by volume), co-mingled with well clean up fluids and diverted into an off-spec cargo tank.

During routine operations, water from the outlet of the HP Separators is sent to the PW treatment system however during well clean ups, the PW treatment system is isolated and any water is directed to an off-spec holding tank.

Once in the holding tank, fluids from well clean ups cannot be re-injected into the reservoir as they can foul the reservoir and reduce overall re-injectivity. It may take up to six days for fluids to reach re-injection specifications, re-injection will recommence once fluids reach specification.

The solids produced during unloading and clean-up are expected to be predominately filter cake from the completion, which is composed of low hardness calcium carbonate. The majority of solids deposit in topsides process vessels and in the off-spec cargo tank, however some residual solids may flow through with the effluent to the Cetco temporary water treatment skid.

To ensure process stability, a minimum number of low water cut wells in the Vincent field will also be online during GE well clean up, with fluids from these wells being directed to HP Separator A. Downstream of HP separator A and B, PW is directed to a common LP Separator and into the PW treatment system. Due to the presence of solids from HP Separator B, the PW treatment system is isolated during this period, which means that PW from Vincent is directed to the holding tank. During well clean ups, PW from Vincent field represents approximately 15% of total volume of water directed to holding tanks. After the initial completion fluids are discharged (approximately 25 m^3), the remaining water produced during well clean ups is primarily condensed water from the new GE wells.

All gas will be directed to HP Compression, as this should be online throughout well clean up. If it is not online or sufficient gas is not available, the gas will be flared. LP Compression should be brought online when there is sufficient gas for stable operation. It is possible that there will not be sufficient gas for normal fuel gas supply. In this case, fuel gas will be supplied by fuel gas blending or sole supply from backflow of Vincent gas injection system. If the Vincent gas injection well is depleted, users will be on a mix of diesel and fuel gas. During well unloading and clean-up of the subsea and topsides, acoustic sand detectors shall be used to monitor and trend the solids content of the produced fluids.

3.7.3 Well Reinjection Well Clean Up

The GE water injection wells will not require clean-up via the NY FPSO. These wells will be cleaned up using water produced from the CWF system, which will be initially injected into the associated water injection wells also injecting the associated completion fluids / solids into the reservoir. No fluids will require treatment or disposal from the NY FPSO from this activity.

The GE water-flood fields will be managed such that 100% voidage replacement is achieved (i.e. the rate at which oil, water and gas is produced is replaced by an equivalent volume of injected water). Water injection wells in the Laverda Canyon field will be tested to establish whether sufficient injection capacity is available to support oil production rate above the 16" production line turndown, nominally 30 kbbl/d. Where injection testing identifies a shortfall in injection capacity above a minimum threshold (nominally 10 kbbl/d per Laverda Canyon injection well), production start-up may be delayed until either additional production wells associated with subsequent RFSU phases becomes available, or poorly performing water injection wells are remediated.

3.7.4 Remaining Start ups

For the remaining production well clean-ups for RFSU 2 through to 4, similar start-up and clean-up methodology will be followed. In particular, all oil and water will be co-mingled and flowed to an off spec cargo tank. From here, water will be de-bottomed and treated in a temporary water treatment package before being discharged overboard.

RFSU 5 covers the CIM water injection well (CIM04WI). Start-up and clean-up of this well will be consistent with the process described in above.

3.8 Subsea Inspection Maintenance and Repair Activities

3.8.1 IMR Activities

A range of subsea inspection, monitoring, maintenance and repair activities (referred to as IMR) may be undertaken during the operations of NY. Subsea IMR activities are typically undertaken from a diving or installation support vessel (support vessel) via one or more ROVs and/or divers. Typical support vessels use DP systems to allow manoeuvrability and avoid anchoring when undertaking works due to the proximity of subsea infrastructure. IMR activities may include:

- Inspections;
- Chemical usage;
- Intervention isolation;
- Pressure and leak testing;
- Flushing;
- Pipeline pigging operations;
- Marine growth removal;
- Sediment relocation;
- Hotstab change out;
- Corrosion protection;
- Span rectification, flowline protection and stabilisation;
- Cycling of valves;
- Choke change out;
- SCM change out;

- Jumper and umbilical replacement;
- Multiphase flow meter change-out;
- Multiphase pump change-out;
- Tree cap change out;
- Chemical injection throttle valve change-out;
- Accumulator skid (barrier fluid top-up);
- Spool repair, replacement and recovery; and
- Suspension and preservation of redundant equipment.

3.8.2 Well Management and Maintenance Activities

NY facility subsea well interventions, workovers and well kills require a suitable vessel or drill rig to accommodate and support intervention packages. Therefore, these activities do not form part of the scope of this EP. Unloading and clean-up from subsea wells via the NY FPSO may be required from time-to-time as described below.

Well Unloading and Clean-up

After well construction, subsea interventions, workovers and well kills, the well may be unloaded and flowed via the process facilities to be cleaned of any remaining chemicals and fluids in the wellbore or reservoir. During this phase, the products may be processed as follows:

- Gas will be routed into the production process where possible, or flared if unsuitable;
- Fluids will be routed to the HP flare knockout drum which discharges liquids to the closed drain system; and
- Wastes (may include fluids and sands/solids) will be managed as appropriate based on composition. Solids will be separated for onshore disposal as required by Woodside's Waste Management Plan for Offshore Facilities. An additional strainer may be placed in the flowlines prior to the main separators to remove any large debris that may be within the well bore.

Prolonged Period of NY FPSO Sailaway

During potential periods of extended FPSO sailway (e.g. when NY FPSO is disconnected and sailed away to the shipyard) normal well monitoring from the FPSO is unavailable. During these periods wells are shut-in and managed in accordance with the accepted *Ngujima-Yin Well Operations Management Plan* (WOMP). In the WOMP, Woodside is adopting the *Oil & Gas UK Well Life Cycle Integrity Guidelines* (WLCIG) (Issue 3, March 2016). By adoption of WLCIG, Woodside can demonstrate alignment with current industry good practice with respect to managing well integrity, through ensuring that the wells barriers are verified, wells are left in a safe state, and the risk of loss of containment is reduced to ALARP.

4. DESCRIPTION OF THE RECEIVING ENVIRONMENT

The existing environment characteristics are described in terms of the Operational Area and Zone of Consequence (ZoC). The Operational Area is located within offshore waters approximately 51 km north-north-west of the town of Exmouth and the wider ZoC which has been identified by hydrocarbon spill modelling of the credible worst-case scenario (loss of well integrity described in **Appendix A**).

4.1 Regional Setting

The Operational Area is located in Commonwealth waters within the Northwest Province, in water depths of approximately 340-849 m. The Northwest Province is part of the wider North West Marine Region (NWMR) as defined under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) (National Oceans Office and Geoscience 2005). The Northwest Province is located offshore (beyond the continental shelf break) between Exmouth and Port Hedland. Water depths in the Northwest Province typically range from 1000 to 3000 m, although the Operational Area is situated on the shallower upper continental slope (Department of Sustainability, Environment, Water, Population and Communities 2012a).

4.2 Physical Environment

The climate of the NWMR exhibits a tropical monsoon climate, with distinct wet (October to April) and dry (May to September) seasons (Pearce et al. 2003). Rainfall in the region typically occurs during the wet season, with highest falls observed during late summer and is often associated with the passage of tropical low pressure systems and cyclones. Rainfall outside this period is typically low.

Winds typically vary seasonally, with a tendency for winds from the south-westerly quadrant during summer months (October – January) and the south-easterly quadrant in winter (April – August). The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. During winter months the relative position of the high pressure cells moves further north, leading to prevailing easterly winds blowing from the mainland. Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, typically April and August.

Cyclones are a relatively frequent event in the region, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast. The cyclone season officially runs from November to April each year although cyclones also occur outside this period (BoM n.d.). Significant storm surge is associated with the passage of a cyclone, which can result in very high tides and coastal flooding.

The large-scale ocean circulation of the NWMR is primarily influenced by the Indonesian Throughflow (ITF), and the Leeuwin Current. Both of these currents are significant drivers of the NWMR ecosystems. The currents are driven by pressure differences between the equator and the higher density cooler and more saline waters of the Southern Ocean, strongly influenced by seasonal change and El Niño and La Niña episodes.

Tides in the NWMR are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards then north-west. The NWMR exhibits a considerable range in tidal height, from microtidal ranges (<2 m) south-west of Barrow Island to macrotidal (>6 m) north of Broome (Brewer et al. 2007, Holloway 1983). Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights.

The Operational Area lies in waters approximately 340 to 849 m deep on the continental shelf. The bathymetry of the north-western part of the Operational area consists of relatively flat and featureless seabed. In the southern part of the Operational Area, the Canyons linking Cuvier Abyssal Plain and Cape Range Peninsula Key Ecological Feature (KEF) (herein referred to as ? the Canyons KEF) intersects the Operational Area. The Canyons KEF consists of offshore, deep water canyon features linking the Cuvier Abyssal Plain and Cape Range Peninsula. As part of this deep water canyon system, the North and South Enfield Canyons (herein referred to as the Enfield Canyon) overlap the south western part of the Operational Area. Within the Operational Area, the Enfield Canyon (a tributary of the Cape Range Canyon) exhibits relatively low topographic relief (20–30 m), with only isolated boulders (sometimes greater than 3 metres in height) observed (BMT Oceanica 2016).

Sediments in the Operational Area are broadly consistent with those in the Enfield Canyon, generally composed of coarser and/or more consolidated sediments as compared to the mid-slope (500 to 1000 m) (BMT Oceanica 2016). Sediments within the Enfield Canyon where they overlap with the Operational Area were found to comprise sand, silt, clays and fines (BMT Oceanica 2016). Isolated areas of hard substrate within the Enfield Canyon were characterised by isolated boulders, and found to be featureless (BMT Oceanica 2016). Sediment quality in the Enfield Canyon was high, with most potential contaminants (metals and hydrocarbons) below recognised guidelines for sediment quality (BMT Oceanica 2016).

Seabed sediments of the continental slope in the Northwest Province are generally dominated by carbonate silts and muds, with sand and gravel fractions increasing closer to the shelf break on the upper slope (Baker et al. 2008). Sediments of the Northwest Province are characterised by fine to medium sediment (silts and sands), with patches of coarser sediments (shells/gravels). Sediment composition was shown to comprise a gradient of finer sediments with increasing depth, and the area is interspersed with smaller patches of more consolidated, coarser sediment and limited rocky outcrops associated with steeper slope areas.

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 Operational Area or wider ZoC.

4.3.1 Benthic Communities

Sea floor communities in deeper shelf waters receive insufficient light to sustain ecologically sensitive primary producers such as seagrasses, macroalgae or reef-building corals. Given the depth of water at the Operational Area (approximately 340–849 m), these benthic primary producer groups will not occur in the Operational Area, but are present within the wider ZoC.

Despite the lack of significant areas of hard substrate within the Operational Area, some deep water filter feeding communities are still expected to be present in the silty clay/sand. The results of the North West Cape Continental Shelf and Slope survey undertaken by the Australian Institute of Marine Science (AIMS) (Heyward et al. 2001) indicated that the distribution of biota in the vicinity of the Operational Area was patchy, with epibenthic fauna demonstrating heterogeneity in abundance and diversity both within and between depths. These differences were more marked on the upper slope and continental shelf stations (50–450 m depth) and appeared to be related, with variation in seabed sediments.

Similarly, recent observations of epifauna in the Enfield Canyon indicated the density of deposit feeding fauna was low and sparsely distributed throughout the surveyed area (BMT Oceanica 2016), which is consistent with results from other investigations in the region (Heyward et al. 2001a, Heyward and Rees 2001). Deposit-feeding fauna (e.g. holothurians and echinoids) were relatively more abundant in the continental slope portion of the canyon than the head of the canyon (on the continental shelf break). Bioturbation was observed within the Enfield Canyon, indicating the presence of burrowing epifauna and infauna (BMT Oceanica 2016).

Benthic Communities in the Wider Region

Coral reefs habitats have a high diversity of corals, associated fish and other species of both commercial and conservation importance. No coral reefs have been identified within or adjacent to the Operational Area; however, coral reef habitats are an integral part of the marine environment within the wider region of the ZoC for several locations (approximate distance and direction from Operational Area in brackets), including:

- Ningaloo Coast World Heritage Area (WHA) (19 km south-west);
- Muiron Islands (35 km south-west); and
- Barrow Island (140 km north-east).

Seagrass beds and macroalgae habitats are present in the wider region of the ZoC, such as the Ningaloo Coast and Muiron Islands, Montebello, Lowendal and Barrow Islands, Pilbara Southern and Northern Island Groups, Shark Bay, Houtman Abrolhos Islands, Jurien Bay, the Kimberley coast and Indonesian shorelines.

Mangrove systems provide complex structural habitats that act as nurseries for many marine species as well as nesting and feeding sites for many birds, reptiles and insects (Robertson and Duke 1987). Mangroves also maintain sediment, nutrient and water quality within habitats and reduce coastal erosion. These coastal habitats can be found in the wider region of the ZoC in locations such as Ningaloo, Shark Bay, the Houtman Abrolhos Islands and Indonesia. Isolated stands also occur on the Montebello Islands.

4.3.2 Pelagic and Demersal Fish Populations

The Operational Area appears to have a relatively high diversity of fish but low abundance. A survey of the Enfield Canyon observed 80 species from 41 families, which is consistent with data from the region more broadly (BMT Oceanica 2016, Last et al. 2005). Ichthyofauna observed during the survey was characterised by macrourid, berycid, morid, liparid, halosaurid and congrid species, consistent with other observations of continental slope fish assemblages in the region (BMT Oceanica 2016). This differed from the assemblages observed in the vicinity of the Operational Area by Heyward et al. (2001a) and Heyward and Rees (2001), who also observed sternoptychid, oreosomatid and nettastomatid fishes. Given the relatively high diversity and low abundance that characterised fish assemblages in the upper continental slope, these differences are expected to be the result of relatively low sampling effort rather than actual differences between the assemblages observed. Note the families observed during surveys in the vicinity of the Operational Area are widely distributed in continental slope habitats, both in Australia and other ocean basins (Last et al. 2005), likely due to the widespread nature of such continental slope habitats and lack of barriers to dispersal.

The Continental Slope Demersal Fish Communities is a KEF in the Operational Area. It has been identified as one of the most diverse slope assemblages in Australian waters. Diversity of demersal fish assemblages on the continental slope between North West Cape and the Montebello Trough is among the highest in Australia (>500 species, of which up to 76 are endemic), with the North West Cape region cited as a transition between tropical and temperate demersal and continental slope fish assemblages (Last et al. 2005). Fish assemblage species richness in the region has been shown to decrease with depth and be positively correlated with habitat complexity (Last et al. 2005).

Fish species in the NWMR (including the Operational Area and much of the ZoC) comprise small and large pelagic fish, as well as demersal species. Small pelagic fish inhabit a range of marine habitats, including inshore and continental shelf waters. They feed on pelagic phytoplankton and zooplankton and represent a food source for a wide variety of predators including large pelagic fish, sharks, seabirds and marine mammals (Mackie et al. 2007). Large pelagic fish in the NWMR include commercially targeted species such as mackerel, wahoo, tuna, swordfish and marlin. Large pelagic fish are typically widespread, found mainly in offshore waters (occasionally on the shelf), and often

4.3.3 Plankton

Plankton within the Operational Area and ZoC is expected to reflect the conditions of the NWMR. Primary productivity of the NWMR appears to be largely driven by offshore influences (as reported by Brewer et al. 2007), with periodic upwelling events and cyclonic influences driving coastal productivity with nutrient recycling and advection. There is a tendency for offshore phytoplankton communities in the NWMR to be characterised by smaller taxa (e.g. bacteria), whereas shelf waters are dominated by larger taxa such as diatoms (Hanson et al. 2007).

Within the wider ZoC, peak primary productivity occurs in late summer/early autumn, along the shelf edge of the Ningaloo Reef. It also links to a larger biologically productive period in the area that includes mass coral spawning events, peaks in zooplankton and fish larvae abundance (Department of Conservation and Land Management 2005), with periodic upwelling throughout the year.

4.3.4 Species

A total of 108 EPBC Act listed marine species were identified as potentially occurring within the Operational area and wider ZoC. Of the species identified by the Protected Matters Search Tool (PMST) report, 50 are listed as threatened and 88 are migratory under the EPBC Act (**Table 4-1**).

Table 4-1 Threatened and Migratory Marine Species under the EPBC Act Potentially Occurring within the Operational Area

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Mammals				
Balaenoptera bonaerensis	Antarctic minke whale, dark-shoulder minke whale	N/A	Migratory	**Ops Area**
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	
Balaenoptera edeni	Bryde's whale	N/A	Migratory	
Balaenoptera musculus	Blue whale	Endangered	Migratory	
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	
Eubalaena australis	Southern right whale	Endangered	N/A	
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	
Orcinus orca	Killer whale, orca	N/A	Migratory	
Tursiops aduncus	Spotted bottlenose dolphin (Arafura/Timor Sea populations)	N/A	Migratory	
Caperea marginata	Pygmy right whale	N/A	Migratory	**ZoC**
Dugong dugon	Dugong	N/A	Migratory	
Lagenorhynchus obscurus	Dusky dolphin	N/A	Migratory	
Neophoca cinerea	Australian sea-lion	Vulnerable	N/A	
Physeter macrocephalus	Sperm whale	N/A	Migratory	
Sousa chinensis	Indo-Pacific humpback dolphin	N/A	Migratory	
Reptiles				
Caretta caretta	Loggerhead turtle	Endangered	Migratory	**Ops Area**
Chelonia mydas	Green turtle	Vulnerable	Migratory	
Dermochelys coriacea	Leatherback turtle, leathery	Endangered	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
	turtle, luth			
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	
Natator depressus	Flatback turtle	Vulnerable	Migratory	
Aipysurus apraefrontalis	Short-nosed seasnake	Critically endangered	N/A	**ZoC**
Lepidochelys olivacea	Olive ridley turtle, Pacific ridley turtle	Endangered	Migratory	
Sharks and Rays				
Anoxypristis cuspidata	Narrow sawfish, knifetooth sawfish	N/A	Migratory	**Ops Area**
Carcharodon carcharias	White shark, great white shark	Vulnerable	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	
Carcharias taurus (west coast population)	Grey nurse shark	Vulnerable	N/A	**ZoC**
Glyphis garricki	Northern river shark, New Guinea river shark	Endangered	N/A	
Lamna nasus	Porbeagle, mackerel shark	N/A	Migratory	
Manta alfredi	Reef manta ray, coastal manta ray, inshore manta ray, Prince Alfred's ray, resident manta ray	N/A	Migratory	
Rhincodon typus	Whale shark	Vulnerable	Migratory	
Fish				
Pristis zijsron	Green sawfish, dindagubba, narrowsnout sawfish	Vulnerable	Migratory	**Ops Area**
Thunnus maccoyii	Southern Bluefin Tuna	Conservation Dependent	N/A	
Pristis clavata	Dwarf sawfish, Queensland sawfish	Conservation Dependent	N/A	
Pristis pristis	Freshwater sawfish, largetooth sawfish, river sawfish, Leichhardt's sawfish, northern sawfish	Vulnerable	Migratory	**ZoC**

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Pristis clavata	Dwarf sawfish, Queensland sawfish	Vulnerable	Migratory	
Pristis pristis	Freshwater sawfish, largetooth sawfish, river sawfish, Leichhardt's sawfish, northern sawfish	Conservation Dependent	N/A	
Birds				
Actitis hypoleucos	Common sandpiper	N/A	Migratory	**Ops Area**
Anous stolidus	Common noddy	N/A	Migratory	
Ardenna carneipes	Flesh-footed shearwater, fleshy-footed shearwater	N/A	Migratory	
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	
Calidris canutus	Red knot, knot	Endangered	Migratory	
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	
Fregata ariel	Lesser frigatebird, least frigatebird	N/A	Migratory	
Macronectes giganteus	Southern giant-petrel, southern giant petrel	Endangered	Migratory	
Numenius madagascariensis	Eastern curlew, far eastern curlew	Critically endangered	Migratory	
Pandion haliaetus	Osprey	N/A	Migratory	
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A	
Sternula nereis nereis	Australian fairy tern	Vulnerable	N/A	
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A	**ZoC**
Ardenna pacifica	Wedge-tailed shearwater	N/A	Migratory	
Arenaria interpres	Ruddy turnstone	N/A	Migratory	
Calidris alba	Sanderling	N/A	Migratory	
Calidris ruficollis	Red-necked stint	N/A	Migratory	
Calidris subminuta	Long-toed stint	N/A	Migratory	
Calidris tenuirostris	Great knot	Critically endangered	Migratory	
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	
Charadrius bicinctus	Double-banded plover	N/A	Migratory	
Charadrius leschenaultii	Greater sand plover, large	Vulnerable	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
	sand plover			
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	Migratory	
Charadrius veredus	Oriental plover, oriental dotterel	N/A	Migratory	
Diomedea amsterdamensis	Amsterdam albatross	Endangered	Migratory	
Diomedea antipodensis	Antipodean albatross	Vulnerable	N/A	
Diomedea dabbenena	Tristan albatross	Endangered	N/A	
Diomedea epomophora	Southern royal albatross	Vulnerable	Migratory	
Diomedea exulans	Wandering albatross	Vulnerable	Migratory	
Diomedea sanfordi	Northern royal albatross	Endangered	N/A	
Fregata andrewsi	Christmas Island frigatebird, Andrew's frigatebird	Endangered	Migratory	
Fregata minor	Great frigatebird, greater frigatebird	N/A	Migratory	
Gallinago megala	Swinhoe's snipe	N/A	Migratory	
Gallinago stenura	Pin-tailed snipe	N/A	Migratory	
Glareola maldivarum	Oriental pratincole	N/A	Migratory	
Halobaena caerulea	Blue petrel	Endangered	N/A	
Hydroprogne caspia	Caspian tern	N/A	Migratory	
Limicola falcinellus	Broad-billed sandpiper	N/A	Migratory	
Limosa lapponica	Bar-tailed godwit	N/A	Migratory	
Limosa lapponica baueri	Bar-tailed godwit (baueri), western Alaskan bar-tailed godwit	Vulnerable	N/A	
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit, bar tailed godwit (menzbieri)	Critically endangered	N/A	
Limosa limosa	Black-tailed godwit	N/A	Migratory	
Macronectes halli	Northern giant petrel	Vulnerable	Migratory	
Numenius minutus	Little curlew, little whimbrel	N/A	Migratory	
Numenius phaeopus	Whimbrel	N/A	Migratory	
Onychoprion anaethetus	Bridled tern	N/A	Migratory	
Papasula abbotti	Abbott's booby	Endangered	N/A	
Phaethon lepturus	White-tailed tropicbird	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Phaethon lepturus fulvus	Christmas Island white-tailed tropicbird, golden bosunbird	Endangered	N/A	
Phaethon rubricauda	Red-tailed tropicbird	N/A	Migratory	
Phalaropus lobatus	Red-necked phalarope	N/A	Migratory	
Philomachus pugnax	Ruff (reeve)	N/A	Migratory	
Phoebetria fusca	Sooty albatross	Vulnerable	Migratory	
Pluvialis fulva	Pacific golden plover	N/A	Migratory	
Pluvialis squatarola	Grey plover	N/A	Migratory	
Rostratula australis	Australian painted snipe	Endangered	N/A	
Sterna dougallii	Roseate tern	N/A	Migratory	
Sternula albifrons	Little tern	N/A	Migratory	
Sula leucogaster	Brown booby	N/A	Migratory	
Sula sula	Red-footed booby	N/A	Migratory	
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	N/A	
Thalassarche cauta cauta	Shy albatross, Tasmanian shy albatross	Vulnerable	Migratory	
Thalassarche cauta steadi	White-capped albatross	Vulnerable	N/A	
Thalassarche impavida	Campbell albatross, Campbell black browed albatross	Vulnerable	N/A	
Thalassarche melanophris	Black-browed albatross	Vulnerable	Migratory	
Thalasseus bergii	Crested tern	N/A	Migratory	
Tringa brevipes	Grey-tailed tattler	N/A	Migratory	
Tringa glareola	Wood sandpiper	N/A	Migratory	
Tringa nebularia	Common greenshank, greenshank	N/A	Migratory	
Tringa stagnatilis	Marsh sandpiper, little greenshank	N/A	Migratory	
Tringa totanus	Common redshank, redshank	N/A	Migratory	
Xenus cinereus	Terek sandpiper	N/A	Migratory	

Seabirds

The Operational Area 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. Several species of birds considered to be Matters of National Environmental Significance (MNES) were identified as potentially occurring within the Operations including the common sandpiper, common noddy, flesh-footed shearwater, sharp-tailed sandpiper, red knot, curlew sandpiper, pectoral sandpiper, lesser frigatebird, southern giant petrel, far eastern curlew, osprey, soft-plumaged petrel, and Australian fairy tern.

A Biologically Important Area (BIA) for the migratory wedge-tailed shearwater overlaps the Operational Area. This BIA is related to breeding of the wedge-tailed shearwater, which occurs in the Pilbara between mid-August and April. The PMST report did not identify wedge-tailed shearwaters within the Operational Area.

Based on the results of two survey cruises and other unpublished records, Dunlop et al. (1988) recorded the occurrence of 18 species of seabirds over the North West Shelf (NWS). These included a number of species of petrel, shearwater, tropicbird, frigatebird, booby and tern, as well as the silver gull.

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 (Bamford et al. 2008). No Ramsar wetlands were identified within the Operational Area. The nearest Ramsar wetlands is Ashmore Reef, approximately 1391 km from the Operational Area and

Marine Mammals

The pygmy blue whale migration BIA off the coast of Western Australia overlap spatially with the Operational Area and the wider ZoC. In addition two foraging BIAs overlap with the wider ZoC, off the Ningaloo Coast (approximately 17 km from the Operational Area at its closest point) and another at the southern extent of the wider ZoC, situated in waters between the Abrolhos Islands and Cape Leeuwin (approximately 722 km from the Operational Area at its closest point). Based on pygmy blue whale migration timing, the species may occur in the Operational Area and wider ZoC between March to April (north-bound migration) and November to December (south-bound migration).

The humpback whale migration BIA overlaps the Operational Area, and a resting BIA situated in Exmouth Gulf to the east of the Operational Area (partially within the wider ZoC) lies approximately 38 km from the Operational Area at its closest point. The species undertakes regular seasonal migrations between feeding grounds in Antarctic waters and breeding and calving grounds off the west Kimberley coastline, particularly Camden Sound (Jenner et al. 2001).

Woodside has conducted marine megafauna aerial surveys that have confirmed that the temporal distribution of migrating humpback whales off the North West Cape has remained consistent since baseline surveys were first conducted in 2000 to 2001. The majority of the whales occurred in depths less than 500 m, with the greatest density of whales concentrated in water depths of 200 to 300 m. Humpback whales are regularly sighted from the NY FPSO during their seasonal migration.

The West Australian distribution shows the Operational Area is not within humpback whale critical habitat (calving feeding and resting areas), but is within the humpback whale ‘core and likely species range’, where humpback whales may be present on a seasonal basis from May to November each year

There is the potential for seven species of cetaceans, including, Bryde’s whale, fin whale, sperm whale, Antarctic Minke whale, killer whale, spotted bottlenose dolphin and indo-pacific humpback dolphin to infrequently transit the Operational Area.

The Operational Area is located offshore in deep water which do not support seagrass habitat and does not contain any critical dugong habitat, the occurrence of dugongs in the area is considered very unlikely. Several dugong BIAs for breeding, calving, foraging and nursing lies within the wider ZoC, approximately 27 km from the Operational Area at its closest point.

Australian sea lions are unlikely to occur in the Operational Area, although were identified as potentially occurring in the wider ZoC. The nearest known significant colony is situated at the Abrolhos Islands, which lie beyond the wider ZoC.

Marine Reptiles

Five of the six marine turtle species recorded for the NWMR have the potential to occur within the Operational Area; the loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle and the flatback turtle. Four of the turtle species (green, loggerhead, flatback and hawksbill) have significant nesting rookeries on beaches along the mainland coast and islands in the wider ZoC. A flatback turtle nesting critical habitat[2] overlaps the Operational Area, and a number of BIAs/critical habitats[2] have been identified in the wider ZoC, including:

- Green turtle: Internesting, nesting, mating, foraging, aggregation and basking BIAs (the nearest of which is approximately 13 km from the Operational Area at the closest point);
- Hawksbill turtle: Internesting, nesting, foraging and mating BIAs (the nearest of which is approximately 13 km from the Operational Area at the closest point);
- Flatback turtle: Internesting, nesting, foraging, mating and aggregation BIAs (the nearest of which is approximately 4 km from the Operational Area at the closest point); and
- Loggerhead turtle: Internesting and nesting BIAs (the nearest of which is approximately 13 km from the Operational Area at the closest point).

Nineteen species of sea snakes were identified as potentially occurring within the NY facility wider ZoC. One of these species, the short-nosed sea snake, is listed as Critically Endangered and identified as occurring within the wider ZoC (although not within the Operational Area). This species has primarily been recorded on the Sahul Shelf at Ashmore Reef and Hibernia Reef. Given the water depth of the Operational Area, sea snake sightings will be infrequent and likely comprise few individuals within the Operational Area.

Sharks, Rays and Fishes

The whale shark was identified as potentially occurring within the Operational Area. It is expected that whale sharks may traverse through the Operational Area during their migrations to and from Ningaloo Reef. However, it is expected that whale shark presence within the area would be of a relatively short duration and not in significant numbers given the main aggregations are recorded in coastal waters, particularly the Ningaloo Reef edge.

Several shark/ray species including the great white, shortfin mako, longfin mako, giant manta ray, grey nurse shark, northern river shark, porbeagle shark, reef manta ray and narrow sawfish may be present within the Operational Area, for short durations when individuals transit the area.

Of the fish species identified as potentially occurring within the Operational Area, 73 are species of pipefish and seahorse. However, bycatch data indicates they are uncommon in deeper continental shelf waters (50–200 m) and therefore, are unlikely to occur within the Operational Area. Within the wider ZoC, seahorses and pipefish may be encountered in a wide variety of shallow habitats, including seagrass meadows, reefs and sandy substrates.

4.4 Socio-Economic and Cultural

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

A search of the National Shipwreck Database indicated that there are no known shipwrecks recorded within the Operational Area. The nearest wreck to the Operational Area recorded in the Australian

[2] Critical habitat identified in the *Recovery Plan for Marine Turtles in Australia 2017–2027* (Commonwealth of Australia 2017)

National Shipwreck Database is Lady Ann, which lies approximately 11 km from the Operational Area at the closest point.

There are no heritage listed sites within the Operational Area; however, there are a number of gazetted and proposed National and Commonwealth heritage places in the wider ZoC, including the Ningaloo Coast World Heritage Area, Shark Bay World Heritage Area, Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves Nominated Heritage Place, Dampier Archipelago (including Burrup Peninsula) Indigenous Heritage Place, the Ningaloo Coast Natural Heritage Place, Shark Bay, Western Australia Natural Heritage Place, the Dirk Hartog Landing Site 1616 - Cape Inscription Area Historic Heritage Place, HMAS Sydney II and HMK Kormoran Shipwreck Sites National Heritage Place, Batavia Shipwreck Site and Survivor Camps Area 1629 National Heritage Place – Houtman Abrolhos, Christmas Islands Natural Areas, Ningaloo Marine Area (Commonwealth Waters) Commonwealth Heritage Place, HMAS Sydney II and HMK Kormoran Shipwreck Sites Commonwealth Heritage Place, Mermaid Reef – Rowley Shoals Commonwealth Heritage Place, and Christmas Island Natural areas Commonwealth Heritage Place.

No Ramsar wetlands overlap the Operational Area. Within the wider ZoC, Ashmore Reef is listed as a Ramsar Wetland, Ashmore Reef was designated as a Ramsar wetland due to its importance in providing a resting place for migratory shorebirds and supporting large seabird breeding colonies (Hale and Butcher 2013).

A number of Commonwealth and State fisheries are located within the Operational Area and wider ZoC including the following:

- North – West Slope Trawl Fishery;
- Southern Bluefin Tuna Fishery;
- Skipjack Tuna Fishery
- Western Deepwater Trawl Fishery;
- Small Pelagic Fishery;
- Southern and Eastern Scalefish and Shark Fishery; and
- Western Tuna and Billfish Fishery

State fisheries designated management areas within the Operational Area or ZoC include the following:

- Albrolhos Islands and Mid-West Trawl Managed Fishery;
- Broome Prawn Managed Fishery;
- Exmouth Gulf Managed Prawn Fishery;
- Gascoyne Demersal Scalefish Managed Fishery;
- Mackerel Managed Fishery;
- Nickol Bay Prawn Managed Fishery;
- Northern Demersal Scalefish Managed Fishery;
- Onslow Prawn Managed Fishery;
- Pilbara Demersal Scalefish Fishery;
- Shark Bay Scallop Managed Fishery;
- Shark Bay Prawn Managed Fishery;
- Shark Bay Crab Managed Fishery;

- Shark Bay Beach Seine and Mesh Net Managed Fishery;
- South Coast Purse Siene Managed Fishery;
- South West Coast Salmon Managed Fishery;
- South West Trawl Managed Fishery;
- Southern Demersal Gillnet and Demersal Longline Managed Fishery;
- West Australian Abalone Fishery;
- West Coast Beach Bait Managed Fishery;
- West Coast Demersal Scalefish Fishery;
- West Coast Deep Sea Crustacean Managed Fishery;
- West Coast Estuarine Managed Fishery;
- West Coast Purse Seine Fishery; and
- West Coast Rock Lobster Fishery.

There are no aquaculture operations within or adjacent to the Operational Area as these operations are typically restricted to shallow coastal waters.

There are no traditional or customary fisheries within the Operational Area, as these are typically restricted to shallow coastal waters and/or areas with structure such as reef. However, it is recognised that Barrow Island, Montebello Islands and Ningaloo Reef, all within the wider ZoC, have a known history of fishing when areas were occupied (as from historical records).

Tourism and Recreation

Tourism activities within the Operational Area are infrequent; however, it is acknowledged that there are growing tourism and recreational sectors in Western Australia and these sectors have expanded over the last couple of decades. Growth and the potential for further expansion in tourism and recreational activities is recognised for the Pilbara and Gascoyne regions, with the development of regional centres and a workforce associated with the resources sector (SGS Economics and Planning 2012). Due to the Operational Area's water depth (approximately 340 to 849 m) and distance offshore, recreational fishing is unlikely to occur in the Operational Area, although historical charter fishing has been recorded within WA-28-L.

Tourism is one of the major industries of the North West Cape area, and contributes significantly to the local economy in terms of both income and employment. The main marine nature-based tourist activities are concentrated around and within the Ningaloo Coast WHA (approximately 19 km from the Operational Area) and North West Cape area, including recreational fishing, snorkelling and scuba diving, whale shark (April to August) and manta rays (year round) encounters, whale watching (July to October), whale encounters (August and November) and turtle watching (all year round) (Schianetz et al. 2009).

Shipping

The NWMR supports significant commercial shipping activity, the majority of which is associated with the mining and oil and gas industries. The AMSA has introduced a network of marine fairways across the NWMR of WA to reduce the risk of vessel collisions with offshore infrastructure. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. None of these fairways intersect with the Operational Area; the nearest fairway is approximately 35 km north-west of the Operational Area at the closest point (**Figure 4-1).**

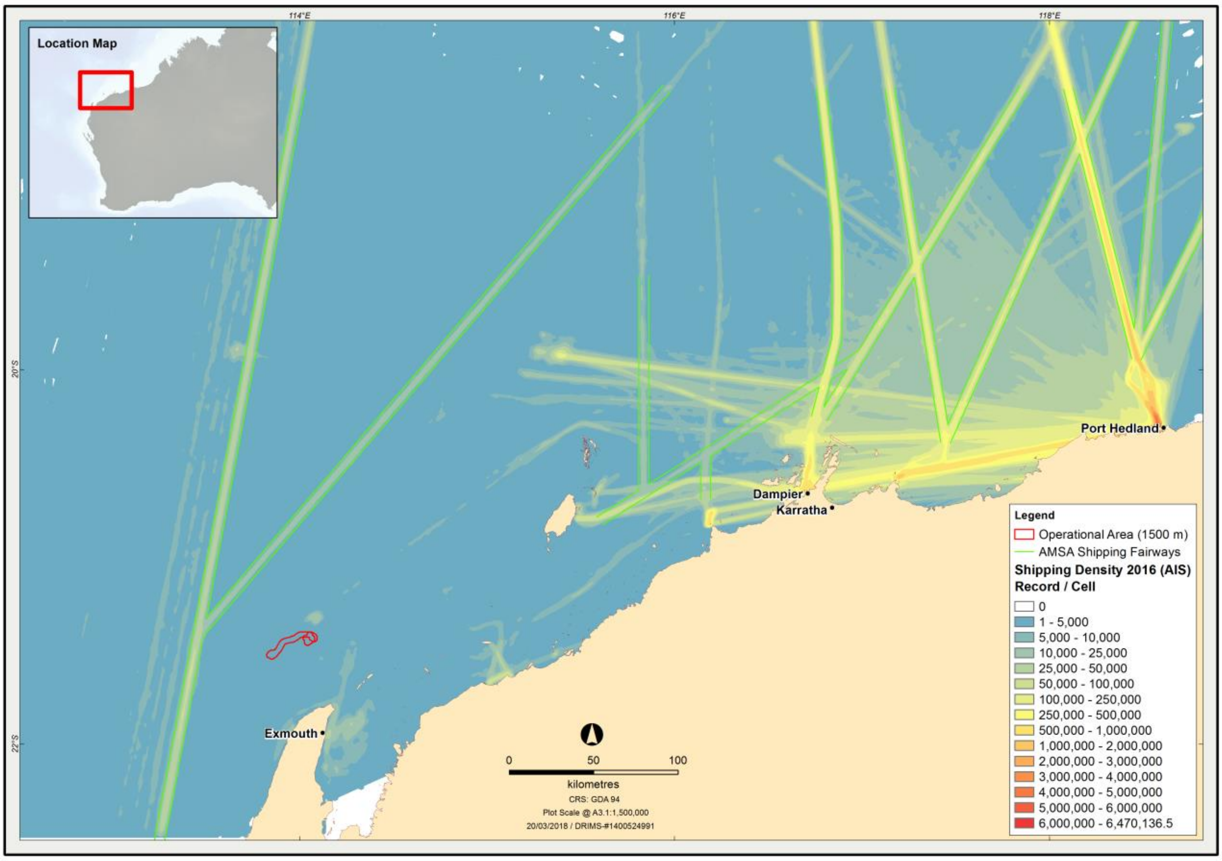

Figure 4-1: Vessel density map in the vicinity of Operational Area from 2016, derived from AMSA satellite tracking system data (vessels include cargo, LNG tanker, ore carriers passenger vessels, support vessels and others/unnamed vessels)

Oil and Gas Infrastructure

The Operational Area is located within an area of established oil and gas operations in the broader NWMR. Several facilities are located in proximity to the Operational Area. Several FPSOs are currently in operation in the vicinity of the Operational Area.

Defence

There are designated defence practice areas in the offshore marine waters off Ningaloo and the North West Cape. The Operational Area is within the northern tip of one of the defence practice areas (**Figure 4-2**). A Royal Australian Air Force base located at Learmonth, on North West Cape, lies approximately 56 km south of the Operational Area.

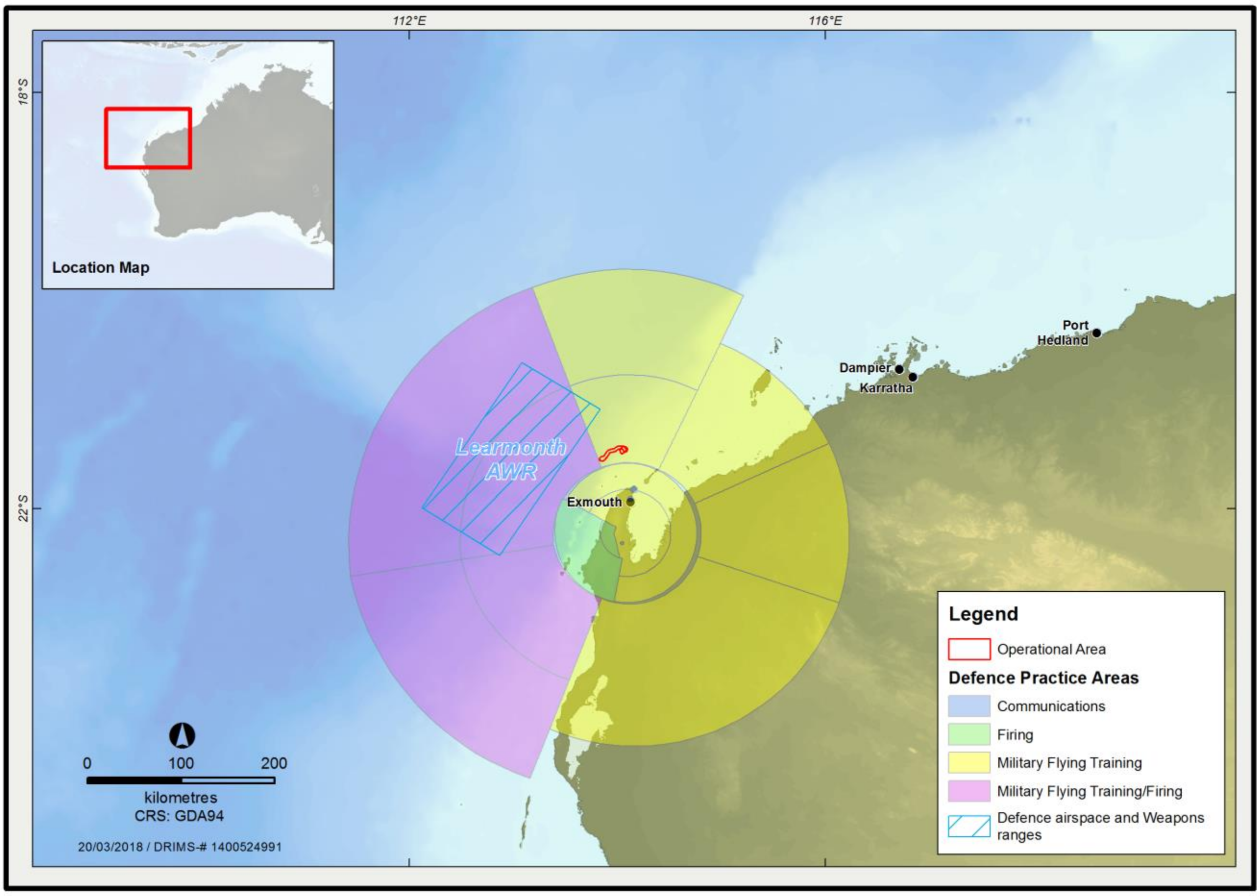

Figure 4-2: Department of Defence Demarcated Marine Offshore Areas for military and defence practise with reference to the location of the Operational Area

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/Barrow/Lowendal Island Group 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 and have been allocated conservation objectives (International Union for the Conservation of Nature (IUCN) Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. These principles determine what activities are acceptable within a protected area under the EPBC Act. As all planned petroleum activities will take place within the Operational Area, and no protected areas overlap this, the planned activities associated with the Petroleum Activities Program will be conducted in a manner consistent with the Australian IUCN reserve management principles for the IUCN categories which have been identified in **Table 4-2** and shown in **Figure 4-3**.

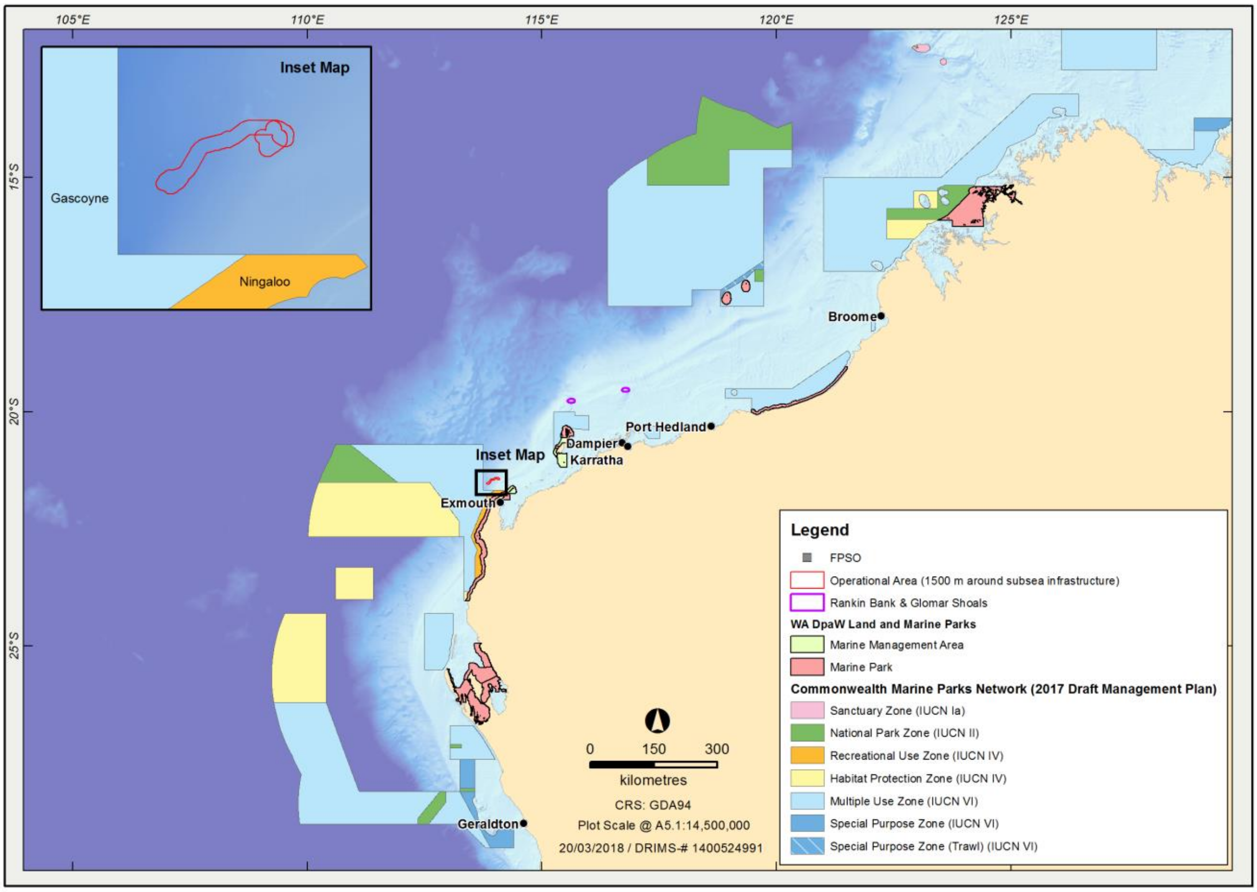

Figure 4-3: Established and proposed Commonwealth and State Marine Protected Areas in Relation to the Operational Area

Table 4-2: Summary of Established and Proposed Marine Protected Areas and Other Sensitive Locations in the Region Relating to the Operational Area

	Distance from Operational Area to Values / Sensitivity boundaries (km)	International Union for the Conservation of Nature (IUCN) Protected Area Category*
Australian Marine Parks (AMPs) (formerly Commonwealth Marine Reserves)		
Gascoyne	8	II, IV and VI
Ningaloo	19	IV
Montebello	137	VI
Shark Bay	315	VI
Carnarvon Canyon	319	IV
Abrolhos	468	II, IV and VI
Argo-Rowley Terrace	197	II and VI
Mermaid Reef	737	II
Kimberley	876	II, IV and VI
Jurien	959	II and VI
Two Rocks	1111	II and VI
Perth Canyon	1126	II, IV and VI
Geographe	1314	II and VI
South-west Corner	1326	II, IV and VI
State Marine Parks and Nature Reserves		
Marine Parks		
Ningaloo	29	IA, II and IV
Barrow Island	143	IA
Montebello Islands	169	IA, II, IV and VI
Shark Bay	376	IA, II and IV
Rowley Shoals	650	IA, II and IV
Jurien Bay	950	IA, II and VI
Marmion	1142	IA, II and IV
Shoalwater islands	1200	VI
Ngari Capes	1327	VI
Marine Management Areas		
Muiron Islands	30	IA and IV
Barrow Island	134	IA, IV and VI

	Distance from Operational Area to Values / Sensitivity boundaries (km)	International Union for the Conservation of Nature (IUCN) Protected Area Category*
Fish Habitat Protection Areas		
Point Quobba	329	IV
Miaboolya Beach	348	IV
Abrolhos Islands	743	IV
Lancelin Island Lagoon	1058	IV
Cottesloe Reef	1172	IV
World Heritage Areas		
The Ningaloo Coast	17	Not applicable
Shark Bay, Western Australia	357	Not applicable
National Heritage Places		
The Ningaloo Coast	19	Not applicable
Barrow Island and the Montebello-Barrow Islands Marine Conservation Reverse	134	Not applicable
Dampier Archipelago (including Burrup Peninsula)	262	Not applicable
Shark Bay, Western Australia	357	Not applicable
HMAS Sydney II and HSK Kormoran Shipwreck Sites	578	not applicable
Commonwealth Heritage Places		
Ningaloo Marine Area- Commonwealth Waters	19	Not applicable
HMAS Sydney II and HSK Kormoran Shipwreck Sites	578	Not applicable
Mermaid Reef – Rowley Shoals	747	Not applicable
Key Ecological Features		
Continental Slope Demersal Fish Communities	Overlaps Operational Area	Not applicable
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	Overlaps Operational Area	Not applicable
Ancient coastlines at 125 m depth contour	19	Not applicable
Commonwealth Waters Adjacent to Ningaloo Reef	19	Not applicable
Exmouth Plateau	66	Not applicable
Glomar Shoals	322	Not applicable
Western Demersal Slope and Associated Fish Communities	468	Not applicable
Wallaby Saddle	482	Not applicable

	Distance from Operational Area to Values / Sensitivity boundaries (km)	International Union for the Conservation of Nature (IUCN) Protected Area Category*
Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals	641	Not applicable
Western rock lobster	681	Not applicable
Ancient coastline at 90-120 m depth	681	Not applicable
Perth Canyon and adjacent shelf break, and other west coast canyons	703	Not applicable
Commonwealth marine environment surrounding Houtman Abrolhos Islands	723	Not applicable
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	723	Not applicable
Canyons linking the Argo Abyssal Plain with Scott Plateau	952	Not applicable
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	1134	Not applicable
Naturaliste Plateau	1314	Not applicable
Commonwealth marine environment within and adjacent to Geographe Bay	1314	Not applicable
Cape Mentelle upwelling	1329	Not applicable
Albany Canyons group and adjacent shelf break	1522	Not applicable

**Conservation objectives for IUCN categories in Table 4-2 include:*

- *IA: Strict nature reserve – protected from all but light human use*
- *II: National park – protects ecosystems and natural values, but facilitate human visitation*
- *IV: Habitat / species management area – conservation of a particular species, taxonomic group or habitat; and*
- *VI: Protected area with sustainable use of natural resources – allow human use but prohibits large scale development*

†Modelling indicated shoreline accumulation above impact threshold only (i.e. no surface, entrained or dissolved hydrocarbons above impact thresholds

5. ENVIRONMENTAL IMPACTS AND RISKS

5.1 Risk and Impact Identification and Evaluation

Woodside undertook an environmental risk assessment (with outputs applicable to the EP provided in **Appendix A**) to identify the potential environmental impacts and risks associated with the operation of the NY FPSO and the control measures to manage the identified environmental impacts and risks to 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 Processes are shown in **Figure 5-1**. A summary of each step and how it is applied to the proposed Program is provided below.

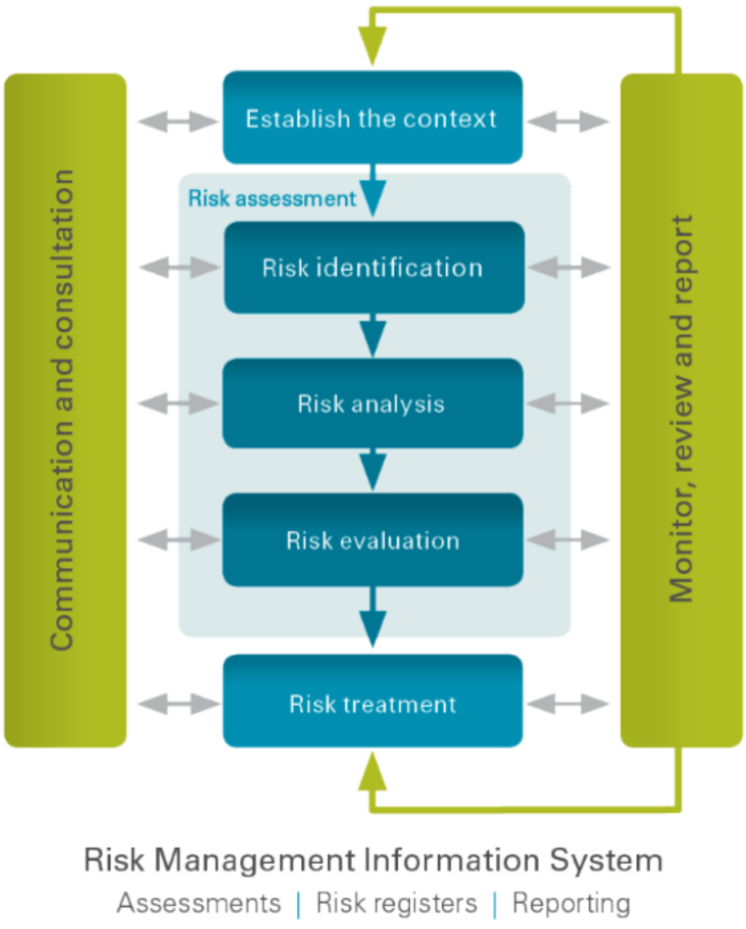

Figure 5-1: Key steps in Woodside's Risk Management Process

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; and
- 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 or impacts is acceptable and ALARP. This is to confirm:

- Activities do not pose an unacceptable environmental risk;
- Appropriate focus is placed on activities where the impact or risk is anticipated to be acceptable and demonstrated to be ALARP; and
- Appropriate effort is applied to the management of risks and impacts based on the uncertainty of the risk, the complexity and risk rating (i.e. potential higher order environmental impacts are subject to further evaluation assessment).

The framework provides appropriate tools, commensurate to the level of uncertainty or novelty (referred to as the decision type A, B or C). The decision type is selected based on an informed discussion around the uncertainty 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 typically involve greater complexity and uncertainty, therefore requiring adoption of the precautionary approach. The risks 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 risk 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 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 all controls (prevention and mitigation) are absent or have failed (refer to **Table 5-1**). Where more than one potential consequence applies, the highest severity consequence 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.

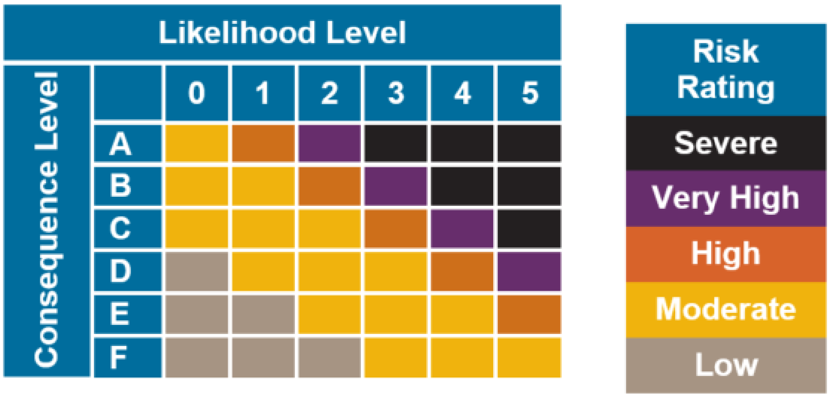

Figure 5-2: Woodside Risk Matrix: Risk Level

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)**

5.2 Classification and Analysis of Major Environment Events

For Woodside's offshore production facilities, a further level of analysis is undertaken to identify, classify and analyse Major Environment Events (MEE). This extra level of rigour is applied to ensure sufficient controls are in place for risks with potential Major and above consequences. In the health and safety area Major Accident Events (MAE) are identified using a similar process which supports consistency in management of key risks within Woodside in accordance with Process Safety Risk Management Procedures.

MEEs are defined by Woodside as:

- An event with potential environment, reputation (pertaining to environment events), social or cultural consequences of category B or higher as per Woodside Risk Matrix (**Figure 5-2**), which are evaluated against credible worst case scenarios which may occur when all controls are absent or have failed.

5.2.1 MEE Identification

The ENVID and risk rating process results in the generation of numerous sources of risk with differing consequence levels. Not all of these risks meet the MEE definition and are therefore screened out at this stage of the MEE process.

Although these risks are screened out, all risks identified in this EP (including MEEs), are evaluated for ALARP and acceptability using the methodology described in **Section 5.3**.

5.2.2 MEE Classification

A standard naming convention has been established for MEEs; this is based around ensuring the MEE titles reflect the cause of the event e.g. 'subsea system loss of containment', rather than the event itself e.g. significant hydrocarbon spill to the marine environment. The MEEs are assigned a unique identification code e.g. MEE-01, MEE-02 etc.

5.2.3 Safety and Environment Critical Elements (SCE) and Performance Standards

Woodside identifies and manages Safety Critical Elements (SCE) technical performance standards and management system performance standards in accordance with Process Safety Management Procedures, Risk Management Procedure, and Change Management Procedures. SCEs are identified for MAE and MEEs. An SCE is a hardware control, the failure of which could cause or contribute substantially to, or the purpose of which is to prevent or limit the effect of a MAE, MEE or Process Safety Event. In addition, Woodside defines Safety and Environment Critical Equipment (SCE) as an item of equipment or structure forming part of a hardware SCE that supports the SCE in achieving the safety function[3].

Once each SCE is selected, technical performance requirements are developed in accordance with Safety and Environment Critical Element (SCE) Management Procedure which form the SCE technical Performance Standards. These standards are a statement of the performance required of a SCE (e.g. functionality, availability, reliability, survivability), which is used as the basis for establishing agreed assurance tasks for each SCE and therefore support the management of operations within acceptable safety and/or environment risks levels, and ensure continuous management of risk to ALARP. An assurance task is an activity carried out by the operator to confirm that the SCE meets, or will meet its SCE Performance Standard. Examples of assurance tasks include inspection routines, test routines, instrumentation calibration and reliability monitoring.

SCE technical Performance Standards are not inherently aligned directly to Environment Performance Standards (EPS), and are used in conjunction with Woodside's management system to identify and treat potential step-outs from expected controls performance or integrity envelopes, and ensure SCE performance can be optimised. Woodside's HSE Event Reporting Guideline describes the identification of 'Damage to SCEs' which is an SCE failure presenting a risk level which requires that Immediate Control Actions must be put in place to manage increased current risk. For applicable SCEs, 'Damage to SCE' failures represent scenarios which may fail to achieve an EPS presented in this EP.

Safety Critical Management System Barriers

For each MEE, Safety Critical Management System specific measures are also identified. These are management system components (generally Woodside Measurement System (WMS) processes) that are key barriers in the management of MEEs.

5.3 Impact and Risk Evaluation

Environmental impacts and risks, as opposed to safety risks, cover a wider range of issues, differing species, persistence, reversibility, resilience, cumulative effects and variability in severity. Determining the degree of environmental risk and the corresponding threshold for whether a risk/impact has been reduced to ALARP and is acceptable is evaluated to a level appropriate to the nature and scale of each impact or risk. Evaluation includes consideration of the following evaluation criteria:

- The Decision Type;
- Principles of Ecologically Sustainable Development as defined under the EPBC Act;
- Internal context - the proposed controls and risk level are consistent with Woodside policies, procedures and standards;
- External context – consideration of the environment consequence and stakeholder acceptability; and
- Other requirements – the proposed controls and risk level are consistent with national and international industry standards, laws and policies.

[3] *Note: not all individual equipment items which make up SCE are safety critical.*

In accordance with Regulation 10A(a), 10A(b) and 10A(c), and 13(5)(b) of the Environmental Regulations, Woodside applies the following process to demonstrate ALARP and acceptability for environmental impacts and risks appropriate to the nature and scale of each impact or risk.

5.3.1 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

Risk	Impact	Decision Type
Low and Moderate	***Negligible, Slight or Minor (D, E or F)***	***A***
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.		
High, Very High or Severe	***Moderate and above (A, B, or C)***	***B and C***
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; • Societal concerns are accounted for; and • The alternative control measures are grossly disproportionate to the benefit gained.		

5.3.2 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

Risk	Impact	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 and 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.

5.4 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.

5.4.1 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.

The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the modelled simulations 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. Stochastic modelling does not represent the extent from a single plill scenario, but the potential area covered by multiple worst case scenarios. The stochastic results indicate the probability of where hydrocarbon might travel, and the time taken 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.

As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different ZoC is presented for each fate.

The spill modelling outputs are presented as threshold concentrations for surface, entrained and dissolved hydrocarbons for the modelled scenarios. Surface spill 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)	Accumulated hydrocarbon (g/m^2)
10	500	500	100

5.4.2 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

5.4.3 Dissolved Aromatic Hydrocarbon Threshold Concentrations

To confirm the appropriate threshold for dissolved hydrocarbon impacts associated with Petroleum Activities Program Woodside examined various ecotoxicology data available. Woodside has undertaken ecotoxicological testing of Vincent crude, which is produced at the NY facility. The other crude hydrocarbons, which are produced at the NY FPSO once the GE Tieback Project is completed, have not been tested. As such, ecotoxicological testing results for Vincent crude have been used to inform the selection of the dissolved hydrocarbon impact threshold, as this is expected to be the most similar to Cimatti and Norton-1 of the hydrocarbons for which ecotoxicology data is available. A summary of crude hydrocarbon characteristics produced at the NY facility is provided in **Table 5-7**.

Table 5-7: Characteristics of the hydrocarbon types used in the modelling of scenarios

Hydrocarbon Type	Initial Density (g/cm^3 at 15°C)	Viscosity (cP @ 20°C)	Component Boiling Point Percentage of Total				Aromatic (%) of whole oil <380°C	Wax Content	Asphaltene Content (%)
			Volatiles <180˚C	Semi volatiles 180–265˚C	Low Volatility (%) 265–380˚C	Residual (%) >380˚C			
			Non-Persistent			Persistent			
Cimatti crude	0.876	8.8	11.6	18.5	41.8	28.1	16.1	0% wt wax	<0.5
Norton-1 crude	0.937	157.5	1	14	37	48	11.7	<5% wt wax	<0.02
Vincent crude	0.948	275.7	0.04	13.24	16.18	70.54	11.1	<5 % wt	-
NY topsides blend	0.927	96.7	3.3	14.8	51.1	30.8	15.0	0% wt wax	<0.2

Marine diesel	0.829	4.0	6	34.6	54.4	5	-	<5% wt	-

Table 5-8 presents the ecotoxicological test results of no observable effect concentration (NOEC) for Vincent crude .

Table 5-8: Summary of Total Recoverable Hydrocarbons NOECs for Key Life-histories of Different Biota Based on Toxicity Tests for WAF of Vincent crude

Biota and Life Stage	Exposure duration	NOEC – Total Recoverable Hydrocarbon concentration of unweathered Vincent crude showing no direct biological effect (ppb)
Sea urchin fertilisation	1 hour	2360 ppb
Sea urchin larval development	72 hours	2360 ppb
Milky oyster larval development	48 hours	2360 ppb
Amphipod acute toxicity test	96 hours	200 ppb
Larval fish imbalance test	96 hours	3256 ppb
Marine algal growth test*	72 hours	2360 ppb

Source: ESA 2012

The ecotox testing focusses on the total petroleum hydrocarbons (TPH) concentration of the water accommodated fraction (WAF) of the hydrocarbon. It 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 on 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 focussed 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 ecotoxicological test results of NOEC for Vincent crude. The range of NOECs for the organisms tested ranged from 200 ppb to 3256 ppb. Based on these ecotoxicology tests, the selected dissolved aromatic hydrocarbon threshold of 500 ppb has been adopted. This 500 ppb threshold is below the NOEC values for five out of the six sensitive organisms tested

5.4.4 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 harmful exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, and so 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 accidental ingestion and through direct contact with organisms, for example through physical coating of gills and body surfaces (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. However, it is likely the 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 oil hydrocarbons. It is therefore expected that the entrained threshold concentration of 500 ppb will represent a potential impact substantially lower than the NOECs presented in **Table 5-8**.

5.4.5 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. Therefore, ≥100 g/m^2 has been adopted as the threshold for shoreline accumulation.

5.5 Potential Environment Risks Not Included Within the Scope of the Environment Plan

The ENVID identified a number of sources of environmental risk/impact as a result of the Petroleum Activity program, that were assessed as not being applicable (not credible) within or outside the Operational Area, and therefore determined to not form part of this EP. This is described in the following section for information only.

Shallow/Near-shore Activities

The Petroleum Activities Program is located in water depths of between approximately 340 and 849 m, and at a distance approximately 35 km from nearest landfall (Muiron Islands). Consequently, risks/impacts associated with shallow/near-shore activities such as anchoring and vessel grounding were assessed as not credible.

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.

Table 6-1: Environmental Risk and Impacts Register Summary

Aspect	Appendix Reference	Source of Impact	Key Potential Environmental Impacts (Refer to Appendix A for details)	Controlled Impact Classification	Residual Impact Level (ALARP controls in place)	Acceptability of Impact
Planned Activities (Routine and Non-routine)						
Physical presence: Disturbance to marine users	A	Presence of NY FPSO and subsea infrastructure excluding and/or displacing other users from Petroleum Safety Zone and Operational Area.	Isolated social impact potentially resulting from interference with other sea users (e.g. commercial and recreational fishing, and shipping).	F	Social and Cultural – No lasting effect (<1 month). Localised impact not significant to areas/items of cultural significance.	Broadly acceptable
Physical presence: Disturbance to seabed	A	Presence of NY facility and subsea infrastructure modifying marine habitats.	Localised modification of seabed habitat (formation of artificial reef) within Operational Area.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed.	Potential slight, localised modification of seabed habitat within Operational Area with slight potential for impacts to water quality and benthic communities.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
Routine acoustic emissions: generation of noise during routine operations	A	Noise generated within the Operational Area from: • NY FPSO and associated infrastructure; • vessels and IMR activities; and • helicopters.	Potential localised behavioural impacts to marine fauna within the Operational Area.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine and non-routine discharges: discharge of hydrocarbons and chemicals during subsea operations and activities	A	Discharge of subsea control fluids.	Localised, decrease in water quality around subsea system within Operational Area with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of hydrocarbons remaining in subsea pipeworks and equipment as a result of subsea intervention works.	Potential slight short-term, localised decrease in water quality at release location during IMR activities.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
		Discharge of chemicals remaining in subsea pipeworks and equipment or the use of chemicals for subsea IMR activities.	Potential slight short-term, localised decrease in water quality at release location during IMR activities.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of minor fugitive hydrocarbon from subsea equipment.	Potential localised decrease in water quality around subsea system within Operational Area with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Non-routine discharges: subsea commissioning and well unloading	A	Discharge of preservation fluid (treated seawater) during flowline dewatering.	Potential slight, short-term decrease in water quality within mixing zone.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
		Discharge of PW from well clean-up during GE start-up.	Potential slight, short-term decrease in water quality within mixing zone.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable

		Discharge of PW during Vincent re-commissioning and GE commissioning.	Potential slight, short-term decrease in water quality within mixing zone.	E		Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
Routine and non-routine discharges: discharges from utility systems and drains	A	Discharge of sewage, grey water and putrescible waste from NY FPSO and vessels to the marine environment.	Localised increase in nutrients and oxygen demand around NY FPSO and vessels.	F	Cumulative E	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of deck water from NY FPSO and bilge water from vessels to the marine environment.	Potential localised, short-term decrease in water quality at discharge location.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of brine from vessels and NY FPSO to the marine environment.	Localised increase in salinity at the discharge location with no lasting effect.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of CWF CIP effluent from NY FPSO.	Potential slight, short-term localised decrease in water quality at discharge location.	E		Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
		Discharge of seawater systems (including cooling water) from NY FPSO and vessels to the marine environment.	Localised increase in water temperature and short-term localised decrease in water quality at discharge location with no lasting effect.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine and non-routine atmospheric emissions: fuel combustion, flaring and fugitives	A	NY FPSO combustion emissions, operational flaring and fugitive emissions and vessel emissions (including incinerators).	Short-term, localised air quality changes, limited to the air shed local to the facility.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
Routine light emissions: light emissions from NY FPSO lighting, vessels operations and operational flaring	A	Light emissions from NY FPSO and vessels.	Negligible, localised potential for behavioural disturbance of species close to NY FPSO and vessels.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Light emissions from NY FPSO during flaring.	Negligible, localised potential for behavioural disturbance of species close to NY FPSO.	F		Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly acceptable

Aspect	Appendix Reference	Source of Risk	Key Potential Environmental Impacts (Refer to Appendix A for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence / Level of Impact	Likelihood	Residual Risk Rating	
Unplanned Events (Accidents / Incidents)								
Unplanned hydrocarbon or chemical release: hydrocarbon and chemical transfer, storage and use	A	Accidental spill of hydrocarbons to the environment during bunkering/refuelling.	Potential minor short-term impacts to the marine environment, including decrease in water quality and minor impacts to marine biota.	D	Environment – Minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly acceptable
		Accidental discharge of chemicals to the marine	Potential minor, short-term impact to the marine environment, including the potential for slight impacts to	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not	2	M	Broadly

Aspect	Appendix Reference	Source of Risk	Key Potential Environmental Impacts (Refer to Appendix A for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence / Level of Impact	Likelihood	Residual Risk Rating	
		environment from storage, use or transfer.	marine biota.		affecting ecosystem function), physical or biological attributes.			acceptable
Unplanned discharges: hazardous and non-hazardous waste management	A	Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.	Potential for isolated, short-term impacts to marine biota.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly acceptable
Physical presence: Vessel collision with marine fauna	A	Physical presence of vessels resulting in collision with marine fauna.	Potential injury or death of marine fauna (single animal), including protected species. No lasting effect to populations.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Physical presence: Introduction of invasive marine species	A	Invasive species in vessel ballast tanks or on vessels/ submersible equipment.	Potential for minor impact to marine ecosystems.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Unplanned Events (Accidents / Incidents) - MEEs								
Unplanned hydrocarbon release: loss of well containment (MEE-01)	A	Loss of hydrocarbons to the marine environment due to a well loss of containment.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: subsea loss of containment (MEE-02)	A	Loss of hydrocarbons to the marine environment due to a subsea flowline and riser loss of containment (GE).	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	B	Environment – Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	2	H	Acceptable if ALARP
		Loss of hydrocarbons to the marine environment due to a subsea flowline and riser loss of containment (Vincent).	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: topsides loss of containment (MEE-03)[4]	A	Hydrocarbon release from topsides process equipment to the marine environment and atmosphere.	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
		Hydrocarbon release from topsides non-process	Potential minor impacts to the marine environment, including disruption to marine fauna (including protected species), and	D	Environment – Minor, short-term impact (1-2 years) on species, habitat (but not affecting	1	M	Acceptable if

4 MEE based on reputational risk

Aspect	Appendix Reference	Source of Risk	Key Potential Environmental Impacts (Refer to Appendix A for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence / Level of Impact	Likelihood	Residual Risk Rating	
		equipment to the marine environment.	potential short-term interference with or displacement of other sea users.		ecosystem function), physical or biological attributes.			ALARP
Unplanned hydrocarbon release: offloading equipment loss of containment (MEE-04)	A	Hydrocarbon release from NY FPSO offloading equipment to the marine environment and atmosphere.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	B	Environment – Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: NY FPSO cargo tank loss of containment (MEE-05)	A	Hydrocarbon release caused by a cargo tank loss of containment.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: loss of structural integrity (MEE-06)	A	Hydrocarbon release caused by a loss of structural integrity, leading to: MEE-02 – Subsea flowline and riser loss of containment; MEE-03 – Topsides loss of containment; MEE-04 – Offloading equipment loss of containment; or MEE-05 – NY FPSO Cargo tank loss of containment.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: loss of marine vessel separation (MEE-07)	A	Hydrocarbon release from flowline and riser to the marine environment and atmosphere.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	B	Environment – Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere (selected cargo tank as bounding case).	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: loss of control of suspended load (MEE-08)	A	Hydrocarbon release from flowline and riser to the marine environment and atmosphere.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines.	B	Environment – Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP

Aspect	Appendix Reference	Source of Risk	Key Potential Environmental Impacts (Refer to Appendix A for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence / Level of Impact	Likelihood	Residual Risk Rating	
			Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.					
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere.	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP

7. ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE

The Petroleum Activities Program will be managed in compliance with the NY Operations 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 NY Facility Operations 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:

- External annual performance reporting to NOPSEMA verify compliance with the environmental performance objectives, standards and measurement criteria outlined in the EP;
- Internal inspection and assurance activities; and
- Environmental emissions/discharge recording systems.

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 NY Operations 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 NY Operations 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 NY Operations 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 NY Operations 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 NY Operations 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 NY Operations 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 NY Operations EP using Woodside's document control process. Minor revisions will be tracked and incorporated during scheduled internal reviews.

8. OIL POLLUTION EMERGENCY RESPONSE ARRANGEMENTS

The documents listed below, meet the requirements of the Environment Regulations relating to hydrocarbon spill response arrangements.

- Oil Pollution Emergency Arrangements (OPEA) (Australia);
- The NY FPSO Oil Pollution First Strike Plan;
- Oil Spill Preparedness and Response Strategy Selection and Evaluation;
- Operational Plans; and
- Tactical Response Plans

8.1 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 Mobile Offshore Drilling Unit to drill intervention well via Memorandum of Understanding with other industry participants;
- Master services agreement with Australian Marine Oil Spill Centre (AMOSC) for the supply of experienced personnel and equipment;
- 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.

All operations personnel involved in crisis and emergency management are required to commit to ongoing training, process improvement and participation in emergency and crisis response (both real and simulated), including emergency drills specific to potential incidents at the NY Facility. Training includes task specific training and role-based training and 'on the job' experience (i.e. participation in crisis or emergency management exercises).

The Corporate Incident Communication Centre (CICC) based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency. The CICC is staffed by an appropriately skilled team available on call 24 hours a day. The purpose of the team is to coordinate rescues, minimise damage to the environment and facilities and to liaise with external agencies.

There are a number of arrangements which in the event of a spill will underpin Woodside's ability to implement a response across its petroleum activities. To ensure each of these arrangements are adequately tested tests are conducted in alignment with the Hydrocarbon Spill Arrangements Testing Schedule which aligns with international good practice for spill preparedness and response management. The schedule identifies the type of test which will be conducted annually for each arrangement, and how this type will vary over a five-year rolling schedule. Testing methods may include (but are not limited to): audits, drills, field exercises, functional workshops, assurance reporting, assurance monitoring and reviews of key external dependencies.

8.2 NY FPSO Oil Pollution First Strike Plan

The NY FPSO 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 facility and subsea support vessels will have Ship Oil Pollution Emergency Plans (SOPEPs) in accordance with the requirements of 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 NY FPSO 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 NY FPSO Oil Pollution First Strike Plan and Oil Spill Preparedness and Response Mitigation Assessment 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. 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 the implemented Operational Monitoring Programs.

- 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 pre-operational NEBA evaluation has identified relief well drilling as the primary source control strategy.
- 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.
- Subsea dispersant injection - The use of subsea dispersants has similar benefits to surface dispersant application including a potential reduction in the volume of hydrocarbons that reach the shoreline thereby reducing impacts to sensitive receptors. In addition to these benefits, subsea dispersant application may greatly reduce volatile organic compound (VOC) levels during surface response operations, reducing risks and hazards to responders.

- Surface dispersant application - Surface dispersant application may reduce surface hydrocarbons and therefore prevent, or reduce the scale of, shoreline contact. Priority would be placed on treating high volume surface hydrocarbons closest to the release location as this is where they are expected to achieve the greatest environmental benefit
- Containment and recovery - Containment and recover is used to reduce damage to sensitive resources by the physical containment and mechanical removal of hydrocarbons from the marine environment. It has a lower capacity for removing surface oil than the application of dispersant but avoids the potential harm created by the dispersant chemicals themselves and the resulting increase in entrained hydrocarbons in the water column.
- Shoreline protection and deflection - The placement of containment, protection or deflection booms on and near a shoreline is a response strategy to reduce the potential volume of hydrocarbons contacting or spreading along shorelines, which may reduce the scale of shoreline clean-up. Hydrocarbons contained by the booms would be collected where practicable
- 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 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 NY Operations 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 NY FPSO Operations 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 NY Operations 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 Safety Authority (maritime safety)	Maritime safety
Australian Hydrographic Service	Maritime safety
Department of Primary Industries and Regional Development (formerly Department of Fisheries (Western Australia))	Fisheries management
Commonwealth Fisheries	Commercial fisheries – Commonwealth • North West Slope Trawl; • Western Tuna and Billfish Fishery; and • Western Deepwater Trawl.
Western Australian Fisheries	Commercial fisheries – State • Pilbara Fish Trawl; • Pilbara Trap; • Marine Aquarium Fish; • Specimen Shell; • Exmouth Gulf Prawn Fishery (M G Kailis); and • West Coast Deep Sea Crustacean.
Department of Defence	Defence estate management
Department of Transport	Hydrocarbon spill preparedness (Western Australian waters)
Commonwealth Fisheries Association	Commercial fisheries – Commonwealth
Western Australian Fishing Industry Council (WAFIC)	Commercial fisheries – State
Exmouth Community Reference Group	Government, industry and community groups
Exmouth Fishing Charter Operators	Vessel activities

Organisation	Relevance
Quadrant Energy and BHP	Nearby titleholders

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 NY Facility Operations 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 (Exmouth and Coral Bay);
- 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; and
- Non-Government Organisations.

10. TITLEHOLDER NOMINATED LIAISON PERSON

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11. ACRONYMS AND ABBREVIATIONS

Term	Description / Definition
AIMS	Australian Institute of Marine Science
ALARP	As Low as Reasonably Practicable
AMSA	Australian Maritime Safety Authority
AMOSC	Australian Marine Oil Spill Centre
APPEA	Australian Petroleum Production & Exploration Association
bbls	barrels
bbl/d	Barrels per day
BIA	Biologically Important Area
CCR	Central Control Room
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CICC	Corporate Incident Communication Centre
CIM	Cimatti
CIP	Clean-in practice
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWF	Customised Water Flood
DCA	Drill centre A
DCB	Drill centre B
DP	Dynamic Positioning
ENVID	Environmental Hazard Identification
Environment Regulations	*Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations* 2009
EP	Environment Plan
EPS	Environment Performance Standards
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*.
ESD	Ecologically Sustainable Development
ESDV	Emergency Shutdown Valve
FPSO	Floating Production, Storage and Offloading facility
GE	Greater Enfield
HP	High Pressure
HVAC	Heating Ventilation and Air Conditioning
ICS	Incident command structure
ID	Inner diameter
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organization
IMR	Inspection, monitoring, maintenance and repair

ITF	Indonesian Throughflow
IUCN	International Union for the Conservation of Nature
KEF	Key Ecological Feature
km	Kilometer
kW	Kilowatt
LAV	Laverda Canyon
LNG	Liquified Natural Gas
LP	Low Pressure
m	Meter
M^3	Cubic meter
MAE	Major Accident Event
MARPOL	International Convention for the Prevention of Pollution from Ships
MEE	Major Environmental Event
MEG	Monoethylene Glycol
Mmscfd	Million standard cubic feet per day
MNES	Matters of National Environmental Significance
MPFM	Multi-phase flow meter
MPP	Multiphase pumping
NOEC	No observed effect concentration
NOL	Norton-over-Laverda
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NRC	North Rankin Complex
NWMR	North-west Marine Region
NWS	North-west Shelf
NY	Ngujima-Yin
OCIMF	Oil Companies International Marine Forum
OCNS	Offshore Chemical Notification Scheme
OD	Outer diameter
OIW	Oil in water
PW	Produced Water
PLONOR	Pose Little or No. Risk to the Environment
PoB	Personnel on Board
ppm	Parts per million
ppb	Parts per billion
RFSU	Ready For Start-up

ROV	Remote Operated Vehicle
SCE	Safety Critical Element
SCSSVs	Surface controlled subsea safety valves
SOPEP	Ship Oil Pollution Emergency Plan
SCE	Safety and Environmental Critical Elements
SCM	Subsea Control Modules
SMP	Scientific monitoring program
STP	Submerged Turret Protection
TPH	Total Petroleum Hydrocarbons
UK	United Kingdom
µm	Micron
UTA	Umbilical Termination Assemblies
WA	Western Australia
WAF	Water accommodated fractions
WAFIC	Western Australian Fishing Industry Council
WHA	World Heritage Area
WLCIG	Well Life Cycle Integrity Guidelines
WMS	Woodside Management System
WOMP	Well Operations Management Plan
Woodside	Woodside Energy Limited (note references to Woodside may also be references to Woodside Petroleum Ltd, Woodside Burrup Pty Ltd or its applicable subsidiaries)
ZOC	Zone of Consequence

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APPENDIX A: ENVIRONMENTAL IMPACTS AND RISKS

Physical Presence: Disturbance to Marine Users

Impacts Evaluation Summary													
Source of Risk / 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
Presence of NY FPSO and subsea infrastructure excluding and/or displacing other users from Petroleum Safety Zone and Operational Area respectively.							X	A	F	-	-	LCS GP PJ	Broadly acceptable

Description of Source of Impact

The NY Facility has been in operation since 2008 and has been marked on nautical charts since that time. The NY FPSO lies within a Petroleum Safety Zone. The Petroleum Safety Zone was gazetted on 13 October 2017 (Notice A575120), and remains in place until revoked. The Petroleum Safety Zone comprises the area within a 500 m radius of the STP mooring system. The 500 m petroleum safety zone is shown as a “Restricted Area” on navigation charts. NOPSEMA prohibits all vessels, other than vessels or classes of vessels specified in the notice and vessels operated by authorised people, from entering or being present in the area of petroleum safety zones without the consent in writing of NOPSEMA. The Petroleum Safety Zone is a critical safety control intended to reduce the likelihood of interactions between vessels and the NY FPSO, which increases safety for both vessels and the NY facility. The NY FPSO is highly visible under most conditions and is well lit, and the nature of the NY FPSO (Suezmax class steel hull) ensures a clear radar return to alert ships fitted with anti-collision radars.

The physical footprint of subsea infrastructure is highly localised and entirely contained within the Operational Area. The Australian Hydrographic Service (AHS) has been notified of the location of subsea infrastructure for marking on nautical charts. Water depths of subsea infrastructure range between approximately 340 and 849 m.

Routine vessel activities associated with the Petroleum Activities Program are concentrated within the Petroleum Safety Zone (e.g. support vessels at the NY FPSO). Subsea support vessels may undertake activities (e.g. IMR activities) within the Operational Area at any time, including the Operational Area beyond the Petroleum Safety Zone. The duration and location of these activities will vary depending on the activity being undertaken. Woodside ensures vessels undertaking the Petroleum Activities Program meet maritime requirements, including appropriate lights and shapes, and communication with other vessels.

Impact Assessment

Exclusion and Displacement of Other Users

Commercial Fishing: Low levels of fishing have been observed since the NY FPSO began operating. Management boundaries for several Commonwealth and State fisheries were identified as overlapping the Operational Area (**Section 4.4**). These are summarised below, along with their potential for displacement by the Petroleum Activities Program:

- Commonwealth:
  - Southern Bluefin Tuna Fishery: no potential for interaction based on current and historical fishing activity. Effort in this fishery is constrained to the southern half of Australia.
  - Skipjack Tuna Fishery: no potential for interaction based on historical fishing activity. Fishery is currently inactive. Historical effort in this fishery is constrained to the southern half of Australia.
  - Western Tuna and Billfish Fishery: no potential for interaction based on current and historical fishing activity. Effort in this fishery is constrained to the southern half of Australia.
  - North West Slope Trawl Fishery: minor potential for interaction based on gear type (seabed trawl). A small portion of the south-western corner of the managed fishery boundary partially overlaps the Operational Area. Historical fishing effort is well beyond the Operational Area and is concentrated on the Kimberley continental slope.
  - Western Deepwater Trawl Fishery: minor potential for interaction based on gear type (seabed trawl). A small portion of the north-eastern managed fishery boundary partially overlaps the Operational Area. Historical fishing effort is well beyond the Operational Area, and is concentrated on the West Coast continental slope, with vessels

operating primarily from Fremantle and Carnarvon. Effort in the fishery is low; no vessels were active in the fishery during 2015–2016.

- State:
- Mackerel Managed Fishery: minor potential for interaction based on current and historical fishing effort. The managed fishery boundary entirely overlaps the Operational Area. The fishery targets a pelagic species using lines, which have little potential for interaction with the Petroleum Activities Program. Historical fishing effort is concentrated in coastal Pilbara reefs north-east of the Operational Area.
- South West Coast Salmon Managed Fishery: no potential for interaction based on historical fishing activity. Historical effort in this fishery is constrained to the southern half of Western Australia.
- West Coast Deep Sea Crustacean Managed Fishery: minor potential for interaction based on gear type (baited pots). The managed fishery boundary entirely overlaps the Operational Area. Historical fishing effort is well beyond the Operational Area, and is concentrated on the West Coast continental slope, with vessels operating primarily from Fremantle and Carnarvon. Effort in the fishery is low; no vessels were active in the fishery during 2015–2016.

As outlined above, historical fisheries status reports indicate that there is very little or no activity associated with these fisheries within the Operational Area. Therefore, displacement or exclusion of commercial fisheries as a result of the Petroleum Activities Program is unlikely.

The presence of subsea infrastructure could present a hazard to bottom trawl fisheries, due to the risk of equipment entanglement and subsequent equipment damage/loss. The North West Slope Trawl Fishery and the Western Deepwater Trawl Fishery overlap the Operational Area and use bottom trawls, although effort in these fisheries has not historically occurred within the Operational Area.

Consultation with fishing industry participants did not indicate any claims or objections from commercial fishers to the Petroleum Activities Program.

The impact to commercial fishers as a result of the Petroleum Activities Program is the potential for highly localised displacement of effort, and of no lasting effect. As no trawling effort is expected to occur in the Operational Area, the potential for trawling gear to be snagged on subsea infrastructure is considered remote.

Traditional Fishing: Traditional fishing in the region is restricted to nearshore waters of the Australian mainland and islands (e.g. Barrow Island). No traditional fishing effort occurs in the Operational Area. Impacts such as displacement of traditional fishing effort will not credibly occur as a result of the Petroleum Activities Program.

Tourism and Recreation: Tourism and recreation activity in the Operational Area is expected to be infrequent. There are no emergent features or natural values within the Operational Area that are considered tourist attractions. Recreational and charter fishing from vessels are the only tourism and recreation activities identified as potentially occurring in the Operational Area. Previously, two recreational marlin charter operators were identified as potentially operating near the Operational Area. During previous (2012) consultation, no concerns were raised from either operator. Previous consultation also indicated recreational fishing associated with the annual GAMEX fishing tournament (usually run in March by the Exmouth Game Fishing Club) may result in increased offshore recreational fishing effort during GAMEX. Operational experience to date has not indicated adverse interactions with recreational fishers occurs during GAMEX. Woodside’s experience gained from operating the Nganhurra and NY FPSOs has shown that very little recreational (including charter) fishing takes place in the vicinity of the Operational Area. This is consistent with stakeholder consultation outcomes.

Given the distance from boating facilities (nearest established boat ramps and marina are at Tantabiddi, approximately 42 km from the Operational Area), lack of natural attractions and water depth of the Operational Area, very little interaction with tourism and recreational activities is expected to occur during the Petroleum Activities Program. As such, impacts to recreational and charter fishing are expected to be localised and of no lasting effect.

Shipping: Significant commercial shipping occurs in the region, with commercial shipping traffic comprising vessels such as:

- Offtake tankers;
- Support vessels for offshore oil and gas activities; and
- Cargo traffic in shipping fairway to the west of the Operational Area.

The presence of support vessels could potentially cause temporary disruption to commercial shipping. The Operational Area is subjected to vessel traffic that is likely to be associated with oil and gas support infrastructure, including support vessels for NY FPSOs in the area. No recognised shipping lanes overlap the Operational Area; the nearest fairway lies approximately 35 km north-west of the Operational Area. Most vessel activity in the vicinity of the Operational Area is associated with nodes such as offshore facilities (e.g. FPSOs) and ports; no such nodes occur within the Operational Area, other than the NY FPSO. Additionally, the NY FPSO has been operational since 2008, and the AHS has been notified of the location of subsea infrastructure for marking on nautical charts. Operational history of the NY FPSO indicates unauthorised commercial vessels enter the Petroleum Safety Zone very rarely. Consultation undertaken in 2012 as part of the EP submission did not identify any concerns from potentially affected shipping parties. Further consultation in 2017 also did not identify any concerns raised by shipping stakeholders.

The presence of the NY FPSO, associated subsea infrastructure and support vessels will not result in impacts to commercial shipping beyond a localised exclusion of shipping traffic from the Petroleum Safety Zone, and the temporary displacement of commercial shipping from subsea support vessels as a result of vessels undertaking activities in the Operational Area. This is considered a localised impact, and of no lasting effect. Shipping from subsea support vessels as a result of vessels undertaking activities in the Operational Area.

Oil and Gas: The nearest other oil and gas facilities are:

- Ningaloo Vision FPSO (Quadrant), approximately 1 km from Operational Area;
- Nganhurra FPSO (Woodside), approximately 3 km from Operational Area; and
- Pyrenees Venture FPSO (BHP Billiton), approximately 10 km from Operational Area.

The Operational Area overlaps the following non-Woodside titles:

- WA-35-L: Quadrant is the titleholder of WA-35-L, which is associated with the Ningaloo Vision FPSO. No subsea infrastructure of the NY facility overlaps WA-35-L, nor does the Petroleum Safety Zone associated with the NY facility overlap WA-35-L. The Operational Area does not overlap any production wells in WA 35 L.
- WA-32-L: BHP Billiton is the titleholder of WA-32-L, which is associated with the Stybarrow field (the Stybarrow Venture FPSO is no longer on station). Subsea infrastructure associated with the NY facility overlapping WA-32-L consists of the rigid flowlines and control umbilicals. The Petroleum Safety Zone around the NY FPSO does not overlap WA-32-L. The Operational Area does not overlap any production wells in WA-32-L.
- WA-43-L: BHP Billiton is the titleholder of WA-43-L, which is associated with the Pyrenees Venture FPSO. No subsea infrastructure of the NY facility overlaps WA-43-L, nor does the Petroleum Safety Zone associated with the NY facility overlap WA-43-L. The Operational Area does not overlap any production wells in WA-43-L.

Quadrant and BHP Billiton did not raise any concerns or objections during consultation in relation to this EP. Woodside routinely consults with other titleholders where activities may affect their functions, interests and activities; no issues were raised by oil and gas stakeholders consulted in relation to this EP. Operational history of the NY FPSO has shown that interactions with other titleholders has not been an issue to date.

Summary of Control Measures

- Marine Orders 21 (Safety of navigation and emergency procedures) 2012;
- Marine Orders 30 (Prevention of Collisions) 2009;
- Implementation of a 500 m petroleum safety zone around NY facility;
- Notify Australian Hydrographic Service (AHS) of location of new permanent NY facility infrastructure to enable update of maritime charts;
- Undertake consultation program to advise relevant persons of the Petroleum Activities Program and provide opportunity to raise objections or claims;
- NY FPSO collision prevention system is implemented to alert marine vessels of the facility location, which reduces the likelihood of adverse interaction with other marine users. Integrity will be managed in accordance with SCE Management Procedure and SCE Technical Performance Standard(s) to prevent environment risk related damage to SCEs for:
  - P33 – Equipment Supporting Marine Navigation (within Operational Area); and
  - P34 – Collision Prevention Systems

Physical Presence: Disturbance to Seabed

Impacts Evaluation Summary													
Source of Risk / 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
Presence of subsea infrastructure (including moorings) modifying marine habitats.		X	X		X			A	F	-	-	LCS GP PJ	Broadly acceptable
Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed.		X	X		X			A	E	-	-		

Description of Source of Impact

Seabed disturbance associated with the Petroleum Activities Program can occur during operations and IMR activities. Subsea infrastructure has been installed throughout the Operational Area. The NY facility also provides hard substrate habitat from the sea surface through the water column to the seabed (i.e. risers and mooring chains), as well as along the seabed (e.g. flowlines, manifolds, rock berms, etc.).

The presence of subsea infrastructure may result in localised scouring around the infrastructure due to currents, subsurface waves and seabed sediment fluid dynamics. Scour around subsea infrastructure is common in marine environments, often addressed during IMR campaigns.

Flowline movement may occur as per design and within integrity margins along flowline corridors. Normal flowline operational movement occurs due to factors such as flowline buckling and walking (for rigid flowlines), and varying metocean conditions. Flowline movement may result in slight, localised impact to soft sediment benthic habitats, typically on the scales varying between metres to tens of metres laterally along the flowline corridors.

To maintain the integrity of subsea infrastructure, Woodside may be required to undertake routine subsea IMR activities. IMR activities may impact the benthic environment in the vicinity of the activity. IMR activities identified as impacting the benthic environment include:

- inspections – minor, localised sediment resuspension by ROV;
- marine growth removal – minor, localised resuspension of sediment; removal of marine biota from subsea infrastructure;
- sediment relocation – minor, localised modification of benthic habitat and sediment resuspension;
- span rectification, flowline protection and stabilisation – minor, localised modification of benthic habitat within the footprint of area subject to rectification/protection/stabilisation;
- jumper and umbilical replacement – minor, localised modification of benthic habitat in the vicinity of the jumper/umbilical; and
- spool repair/replacement – minor, localised modification of benthic habitat in the vicinity of the spool.

The area of benthic habitat predicted to be impacted varies depending on the nature and scale of the IMR activity. Span rectification activities potentially required for rigid flowlines (such as those used for GE) are considered IMR activities with the greatest potential to modify benthic habitats, due to the alteration of the existing soft sediment habitat to hard substrate. Woodside's operational experience indicates these activities are typically restricted to relatively short (tens of metres) linear sections of flowline, with areas of up to approximately 100 m^2 impacted.

Note that anchoring (aside from the mooring anchors installed for the NY FPSO) will not occur during the Petroleum Activities Program due to the water depth of the Operational Area (>340 m).

Impact Assessment

Flowline movement is limited to within design and integrity envelopes, and may result in slight, localised impact to soft sediment benthic habitats, typically on the scales varying between meters to tens of meters laterally along the flowline corridors.

- IMR activities can be categorised into two potential impacts:
- Direct physical disturbance of benthic habitat; and

- Indirect disturbance to benthic habitats from sedimentation.

Water Quality

Indirect seabed disturbance may include localised and temporary decline in water quality due to increased suspended sediment concentrations and increased sediment deposition caused by IMR activities. However, sediment loads are not expected to be significant due to the relatively small footprint for each activity.

Each discrete IMR activity near the seabed is likely to cause a brief disturbance which may result in a transient plume of suspended sediment. This plume will subsequently be deposited down current as particles resettle. Such localised and short-term events may affect small areas of the seabed and consequently, impact the associated biota (typically sparsely distributed infauna and sessile epifauna). Such impacts are expected to be minor (e.g. ingestion of suspended sediment); impacts such as smothering of sessile biota are not expected to occur.

Other Benthic Communities / Deep Water Filter Feeders

The benthic habitat within the Operational Area is predominantly soft sediment with sparsely associated epifauna, which is broadly represented throughout the Northwest Province. Benthic communities of the soft sediment seabed are characterised by burrowing infauna such as polychaetes, with biota such as sessile filter feeders occurring on areas of hard substrate (such as subsea infrastructure).

IMR activities such as span rectification, flowline protection and stabilisation will typically disturb a small area (typically <100 m^2) of soft sediment habitat. The estimated overall extent of such direct seabed disturbance is extremely small in relation to the extent of the soft sediment habitats, which are broadly represented within the Operational Area and the wider Northwest Province.

Artificial Habitats

Subsea infrastructure is often colonised by marine organisms; the availability of hard substrate is often a limiting factor in benthic communities. As such, the presence of infrastructure has led to the development of ecological communities which would not have existed otherwise (e.g. fouling communities on risers). IMR activities may disturb these new communities, however it is expected that recolonisation will occur. The NY FPSO has the potential to attract birds; however, no population-level impacts will occur as a result of this.

The provision of artificial habitat associated with the NY FPSO and subsea infrastructure will have either no adverse environmental impact or a low level of positive environmental impact through increasing biological diversity.

Values and Sensitivities

Canyons KEF

The upper, easternmost portion of the Canyons KEF overlaps the Operational Area. Sections of the KEF have been shown to host relatively more diverse and abundant biota when compared to the surrounding seabed beyond the canyons. Given the nature and scale of the Petroleum Activities Program, no adverse impacts to the ecological values of the KEF are expected to occur.

Continental Slope Demersal Fish Communities KEF

A small portion of the southern extent of the Continental Slope Demersal Fish Communities KEF overlaps the Operational Area. As outlined in the discussion on benthic habitats above, changes to demersal fish communities as a result of the Petroleum Activities Program are expected to result in a localised increase in diversity and abundance of fish in the immediate vicinity of subsea infrastructure. No impacts to the ecological values of the Continental Slope Demersal Fish Communities KEF will occur as a result of the Petroleum Activities Program.

Summary of Control Measures

- All vessels used for IMR activities will be DP capable; and
- Monitoring and maintenance of subsea infrastructure to manage scour and flowline movement within integrity envelope.

Routine Acoustic Emissions: Generation of Noise during Routine Operations

Impacts Evaluation Summary														
Source of Risk / 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
Noise generated within the Operational Area from: • NY FPSO and associated infrastructure; • Vessels and IMR activities; and • helicopters.						X		A	F	-	-	LCS GP PJ	Broadly acceptable

Description of Source of Impact

The NY facility, vessels, IMR equipment and helicopters will generate noise both in the air and underwater due to the operation of machinery, propeller movement, etc. Typical noise levels for these sources are provided in **Table 12-1**, with more detailed descriptions below. This noise 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 1 µPa (RMS SPL) under windy conditions (McCauley 2005).

Table 12-1: Indicative source characteristics of underwater noise associated with the Petroleum Activities Program

Acoustic Noise Sources	Estimated Sound Pressure Level (dB re 1 µPa rms SPL)	Frequency Range
Vessels (Continuous)		
FPSO	174	Broadband
Support vessel using DP	182	Broadband
IMR Activity Noise (Impulsive)		
Multibeam Echo Sounder	214	200–300
Side Scan Sonar	226	120–410
Sub-bottom Profiler (CHIRP)	205	1–12
Sub-bottom Profiler (Pinger)	214	2–12
Sub-bottom Profiler (Boomer)	212	0.5–5
Wellhead, Flowlines and Subsea Infrastructre (Continuous)		
Wellhead	113	Broadband
Choke valve	155	Broadband

Vessels

The main source of noise from vessels (both facility support and subsea support vessels) relates to using DP thrusters (i.e. cavitation from thruster propellers). Thruster noise is typically high intensity and broadband in nature, with sound pressure levels of 137 dB re 1 µPa at 405 m from a typical offshore support vessel holding station in strong currents (McCauley 1998). McCauley (2005) measured underwater broadband noise up to approximately 182 dB re 1 µPa at 1 m (rms SPL) from a support vessel holding station in the Timor Sea; it is expected that noise levels up to this level may be generated by vessels using DP during the Petroleum Activities Program. Thruster noise from vessels holding station is typically the most intense underwater noise source from vessel activities; other sources from vessels (e.g. main engines when underway, machinery noise transmitted through the hull, etc.) are typically considerably lower intensity noise (McCauley 1998). Note that vessels undertaking the Petroleum Activities Program inherently minimise the use of DP, and there is little potential to further reduce DP use.

All support vessels 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 are travelling slower; slower vessel speeds may reduce underwater noise from machinery (main engines) and propeller cavitation.

IMR Activity Noise

Acoustic survey may be undertaken as part of IMR activities including SSS, MBES and SBP surveys. These methods are typically used infrequently (e.g. SSS generally used for up to five days every four years); these acoustic sources are not constantly active during these infrequent IMR activities. Indicative source characteristics for typical acoustic survey equipment are provided in **Table 12-1**.

Helicopters

Helicopter engines and rotor blades are recognised as a source of noise emissions. Activities relevant to the Operational Area will relate to the landing and take-off of helicopters on the NY facility and potentially subsea support vessels. During these critical stages of helicopter operations, safety takes precedence.

Helicopter noise is emitted to the atmosphere during routine helicopter flights. Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance has been measured at a maximum of 90.6 dB (BMT Asia Pacific 2005).

Helicopter flights are at their lowest (i.e. closest point to the sea surface) during periods of take-off and landing from helidecks, which constitutes a relatively short phase of routine flight operations.

Wellhead, Flowlines and Subsea infrastructure

The noise produced by an operational wellhead was measured by McCauley (2002a). The broadband noise level was very low, 113 dB re 1 μPa, which is only marginally above rough sea condition ambient noise. For a number of nearby wellheads, the sources would have to be in very close proximity (<50 m apart) before their signals summed to increase the total noise field (with two adjacent sources only increasing the total noise field by three dB). Hence, for multiple wellheads in an area, the broadband noise level in the vicinity of the wellheads would be expected to be of the order of 113 dB re 1 μPa. This would drop very quickly to ambient conditions on moving away from the wellhead, falling to background levels within <200 m from the wellhead.

Based on the measurements of wellhead noise discussed in McCauley (2002a), which included flow noise in flowlines, noise produced along a flowline may be expected to be similar to that described for wellheads, with the radiated noise field falling to ambient levels within a hundred metres of the flowline.

Woodside has undertaken acoustic measurements on noise generated by operating choke valves associated with the Angel platform (JASCO Applied Sciences 2015). These measurements indicated choke valve noise is continuous, and the frequency and intensity of noise emitted depends on the rate of production from the well. Noise intensity at low production rates (16% and 30% choke positions) were approximately 154-155 dB re 1 μPa, with higher production rates (85% and 74% choke positions) resulting in lower noise levels (141-144 dB re 1 μPa). Noise from choke valve operation was broadband in nature, with most noise energy concentrated above 1 kHz. Subsea gas wells, such as those in the Angel study, experience higher flow velocities compared to oil wells; as such, the above noise intensity ranges are considered a conservative approximation for NY facility operations.

FPSO Machinery

The NY FPSO may use its main engines when manoeuvring on, or disconnected from, the STP mooring, which will generate underwater noise from hull vibrations and propeller cavitation. These activities are typically of short duration. Machinery such as topside processing equipment may generate noise emissions. Noise emitted by topsides equipment is considered unlikely to contribute significantly to underwater noise levels. However, topsides equipment and other machinery may contribute to hull vibrations, which may then be transmitted into the sea through the NY FPSO hull acting as a transducer. Such noise is typically constant during routine operations.

Measurement of underwater sound taken at the NY FSPO during 2010 during normal operations under calm conditions recorded average broadband source levels of 174 dB re 1 µPa. It was also observed that the NY FPSO was quieter than support vessels that were operating nearby (JASCO Applied Sciences 2010). Source levels from the NY FPSO were comparable to source levels recorded from the Cossack Pioneer FPSO during normal operations, which ranged up to 181 dB re 1 µPa2 m2. This included measurements when its propeller was in use (slowly turning) (McCauley 2002b). This higher source level recorded at Cossack Pioneer is considered representative of the source level at NY FPSO at intermittent times when there is a requirement to use its main engine and propeller.

The HP and LP flare system will generate noise from combustion. Noise from flaring represents a health and safety risk to personnel, and was considered in the design of the NY FPSO to manage the associated occupational health and safety risks (e.g. height specification of flare tower). Noise from flaring is emitted at the top of the flare tower, which is approximately 90 m above the main deck. Noise from the tip of the flare is not constrained and will spread spherically in all directions.

Impact Assessment

Underwater Noise

The Petroleum Activities Program is in waters between approximately 340 and 849 m deep. The values potentially impacted are predominantly pelagic species of fish, and migratory species such as 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):

- by causing direct physical effects on hearing or other organs, including:
  - mortality/potential mortal injury resulting from exposure to noise (not considered credible given the noise sources associated with the Petroleum Activities Program);
  - permanent threshold shift (PTS) – permanent reduction in the ability to perceive sound following exposure to noise; and
  - temporary threshold shift (TTS) – temporary reduction in the ability to perceive sound following exposure to noise, with hearing returning to normal.
- by masking, or interfering with, other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey); and
- through disturbance leading to behavioural changes or displacement from important areas.

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

To inform the assessment, the impact thresholds provided in **Table 12-2** were considered in relation to the credible sources of acoustic emissions.

Table 12-2: Impact Threshold for Environmental Receptors Based On *Southall et al. (2007) and †Popper et al. (2014)

Receptor	Mortality and potential mortal injury	Impairment			Behaviour
		PTS	TTS	Masking	
Low-frequency cetaceans*	192 db re 1 µPa²s M-weighted SEL	198 db re 1 µPa²s M-weighted SEL	183 db re 1 µPa²s M-weighted SEL	-	120-160 dB re 1 µPa rms SPL
Mid-frequency cetaceans*	198 db re 1 µPa²s M-weighted SEL	198 db re 1 µPa²s M-weighted SEL	183 db re 1 µPa²s M-weighted SEL	-	90-170 dB re 1 µPa rms SPL
High-frequency cetaceans*	179 db re 1 µPa²s M-weighted SEL	198 db re 1 µPa²s M-weighted SEL	183 db re 1 µPa²s M-weighted SEL	-	90-140 dB re 1 µPa rms SPL
Fish: no swim bladder†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder no involved in hearing†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing†	(N) Low (I) Low (F) Low	170 dB rms SPL for 48 hrs	158 dB rms SPL for 12 hrs	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low

Note: a range of sound units are provided in the table above, reflecting the range of studies from which these data have been derived. The difference in units presents difficulty in reliably comparing threshold values. Where practicable, the threshold values have been compared with indicative sound sources levels of the same sound unit types to facilitate comparison. The sound units provided in the table above include:

- M-weighted sound exposure level (SEL): a weighted sound metric that emphasises the audible frequency bands for the receptor groups – low, mid- and high frequency cetaceans. SEL units are time integrated and best suited for continuous noise sources, such as vessels holding station or continuous machinery noise.
- Root mean square (rms) sound pressure level (SPL): root mean square of time-series pressure level, useful for quantifying continuous noise sources (as per SEL point above).
- Relative risk (high, medium and low) is given for fish (all types), turtles and eggs and larvae at three distances from the source defined in relative terms as near (N), intermediate (I) and far (F) (after Popper et al. 2014).

Vessel Noise

Using the thruster noise measured by McCauley (1998) as an indicative value for the potential thruster noise generated by vessels during the Petroleum Activities Program and the thresholds presented in Table 5 4, the potential for noise induced mortality, PTS and TTS of cetaceans, fish, sea turtles and eggs/larvae is not considered credible. However, masking and behavioural impacts may occur in close proximity (e.g. <1000 m) to the noise source. Using a simple cylindrical geometric spreading equation to estimate transmission loss (TL) of thruster noise at 182 dB re 1 µPa at 100 Hz (Table 5 5), potential impacts may include:

- Cetaceans: Potential behavioural disturbance out to approximately 1 km for low frequency cetaceans (e.g. humpback whales) and 10 km for mid- and high frequency cetaceans (e.g. coastal dolphins);
- Fish: Potential making and behavioural disturbance at near and intermediate range; likelihood of TTS is considered not to be credible given fish would move away from the source. Site attached fish (e.g. demersal fish at Rankin Bank, approximately 3.5 km from the Operational Area) are not expected to be exposed to underwater noise above impact thresholds; and
- Turtles: Potential masking and behavioural disturbance at intermediate and far range.

Note the estimates in **Table 12-3** are considered to under-estimate transmission loss, and are, hence, inherently conservative, due to:

- use of low frequency (100 Hz) component of thruster noise signature; note thruster noise is typically broadband in nature, with much of the noise energy at frequencies > 100 Hz, which are absorbed more rapidly in seawater; and
- use of high intensity thruster noise (i.e. thruster operating at full power); most time using thrusters is at lower than full power, with concomitant reduction in cavitation noise intensity.

Table 12-3: Estimated Sound Transmission Loss for a 182 dB re 1 µPa Source at 100 Hz Frequency

Range (m)	Transmission Loss	Received Noise (dB re µPa)
100	40.1	141.9
500	54.5	127.5
1000	61.0	121.0
2000	68.0	114.0
5000	79.0	103.0
10,000	90.0	92.0

Fauna such as cetaceans, fish, and turtles are capable of moving away from potential noise sources, and there are no constraints to the movement of these fauna within the Operational Area.

Cetaceans

As the migration corridor BIAs for pygmy blue whales and humpback whales overlap the Operational Area, there is the potential for these species to be exposed to underwater noise levels that may alter their behaviour when they are present in the region during seasonal migrations. Tagging studies of pygmy blue whales have shown the migratory pathway appears to be in deeper water to the west of the Operational Area, and pygmy blue whales have not been observed from the NY FPSO (unlike humpback whales). Given the underwater noise levels that may credibly be generated during the Petroleum Activities Program, and the low likelihood of pygmy blue whales being present in the Operational Area, the potential for impact is considered highly unlikely.

Aerial surveys of humpback whales off North West Cape did not observe any apparent displacement of humpback whales from the area around the NY FPSO (RPS Environment and Planning 2010a). The majority of humpback whales observed during these surveys were east of the NY FPSO, which is consistent with other surveys showing the majority of humpback whales migrate within continental shelf waters along Western Australia (Double et al. 2010, 2012a, Jenner et al. 2001). Received noise levels are expected to reduce to 121 dB re µPa within 1 km of the NY FPSO, which is just above the threshold for behavioural impacts for low frequency cetaceans (120 dB re µPa) (McCauley, 1998). Humpbacks are regularly observed in close proximity to the NY FPSO and vessels. Given the maximum source of noise is below TTS and avoidance behaviour is not observed, it is unlikely humpbacks are adversely impacted by noise from the operation of the NY facility. Hence, pygmy blue and humpback whales are unlikely to be impacted by underwater noise generated during the Petroleum Activities Program.

Mid and high frequency cetaceans (e.g. dolphins) are known to show behavioural disturbance at a range of received noise levels (Southall et al. 2007). Mid and high frequency cetaceans may exhibit short-term behavioural responses to increased levels of underwater noise, such as avoidance or attraction. Dolphins are not expected to frequent the Operational Area.

Several other FPSOs operate in the region; noise emissions from these may act synergistically to increase the size of the area avoided by cetaceans.

Fish

Demersal and pelagic fish species are present in the Operational Area, including fish communities associated with the Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula and the Continental Slope Demersal Fish Communities KEFs.

Potential impacts to fish (including whale sharks) are expected to be restricted to masking and behavioural disturbance. Fish may temporarily be displaced from the immediate vicinity of a noise source; however, they would be expected to behave normally once the noise emissions ceased.

Note that a foraging BIA for whale sharks lies approximately 6 km from the Operational Area at the closest point, and this species may be seasonally present (particularly between March and July) during their annual migration to, and from, the aggregation area off Ningaloo Reef. Note that whale sharks are not considered to be particularly vulnerable to underwater noise, as they do not have a swim bladder (considered to increase the vulnerability of a fish to noise related impacts). Received noise levels are expected to reduce to 103 dB re µPa within 5 km of the operational area (McCauley, 1998). Such sound exposure levels may result in masking or behavioural impacts at worst (Popper et al. 2014). Potential impacts to whale sharks are expected to consist of no more than a short-term temporary displacement from noise sources while transiting the Operational Area.

Turtles

Turtles may occur in the Operational Area (critical nesting habitat defined in the 'Recovery plan for marine turtles in Australia 2017-2027' (Commonwealth of Australia 2017) overlaps the Operational Area), although it does not contain known foraging habitat. Turtles may exhibit behavioural responses when exposed to underwater noise, such as diving. Such disturbances are not expected to have any significant effect on individual turtles. As such, no significant impacts to marine turtles from underwater noise are expected. While uncommon, turtles have been observed in close proximity to the NY FPSO during normal operations, suggesting noise-related impacts during routine operations are not sufficient to deter turtles from the Operational Area.

IMR Activity Noise

Underwater noise from multibeam and side scan sonar will attenuate rapidly in the water column due to the relatively high frequency of noise emissions from these sources. No significant impacts to sensitive fauna are expected to occur as a result of these sources.

Sub-bottom profilers are typically lower frequency than multibeam echo sounders or side scan sonar, and acoustic emissions from sub-bottom profilers may propagate further in the water column. Based on typical source levels and frequencies for sub-bottom profilers, and the geometric spreading equation present in Vessel Noise above, received levels from a sub-bottom profiler will attenuate to 160 dB re 1 µPa rms SPL within approximately 250 m of the source. This is comparable to the noise potentially produced by thrusters (refer to Vessel Noise Section above for a discussion of potential impacts), although sub-bottom profiler emissions are impulsive rather than continuous.

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 Operational Area (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance to marine fauna are not considered credible.

Wellheads, Flowlines and NY FPSO Machinery Noise

Given the low levels of noise emitted by subsea infrastructure such as wellheads, choke valves, flowlines and the NY FPSO hull, no impacts to marine fauna from these noise sources are expected. Measurements of noise generated by choke valves indicated it is relatively high frequency (>1 kHz), and hence will attenuate over relatively short distances in the water column; significant impacts to marine fauna are not considered credible.

Flare noise, like helicopter noise, is generated in the atmosphere and has limited potential to propagate in the sea due to the high acoustic impedance of water. Additionally, the height of the flare tower and the unconstrained propagation of noise from the flare in the atmosphere means the potential for impacts to fauna at or near the sea surface is inherently highly unlikely. Receptors above the water, such as birds, may be exposed to noise from the flare. Operational experience indicates birds routinely roost at a range of locations on the NY FPSO and do not experience any discernible behavioural disturbance due to noise from the flare. As such, impacts to sensitive receptors from flare noise will have no lasting effect and will be highly localised.

Cumulative Impacts

While several FPSOs lie in the vicinity of the NY FPSO, the potential for significant cumulative impacts is considered to be not credible. In-field underwater measurements of FPSO noise off North West Cape indicated noise levels were lower than predicted and did not exceed 130 dB re 1 µPa beyond 500 m from the FPSO (JASCO Applied Sciences 2010). This study concluded that propeller noise was the greatest component of underwater noise; given the FPSO is held on station by moorings, its potential to generate noise is relatively low.

Summary of Control Measures

- Maintain helicopter separation from cetaceans as per EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07), which include the following measures:
  - Helicopters shall not operate lower than 1 650 feet or within a horizontal radius of 500 m of a cetacean known to be present in the area, except for take-off and landing

Routine and Non-Routine Discharges: Discharge of Hydrocarbons and Chemicals during Subsea Operations and Activities

Impacts Evaluation Summary													
Source of Risk / 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
Discharge of subsea control fluids.		X	X		X			A	F	-	-	LCS GP PJ	Broadly acceptable
Discharge of hydrocarbons remaining in subsea pipeworks and equipment as a result of subsea intervention works.		X	X		X			A	E	-	-		
Discharge of chemicals remaining in subsea pipeworks and equipment or the use of chemicals for subsea IMR activities.		X	X		X			A	F	-	-		
Discharge of minor fugitive hydrocarbons from subsea equipment.			X					A	F	3	M		

Description of Source of Impact

Hydrocarbons and chemicals may be discharged as a result of planned routine and non-routine operations and activities, including:

Operational discharges including:

- Discharge of subsea control fluids - subsea control fluid is used to control subsea and well-head valves remotely from the facility. It is an open-loop system, designed to release control fluid from the subsea system;
- Potential non-routine hydraulic fluid discharge associated with umbilical system losses/weeps; and
- Discharge of minor fugitive hydrocarbon from subsea equipment (e.g. seal weeps/bubbles).

IMR activities including;

- Discharge of residual hydrocarbons in subsea lines and equipment as a result of subsea IMR activities; and
- Discharge of residual chemicals in subsea lines and equipment or the use of chemicals for subsea inspection, maintenance and repair (IMR) activities (including installation of pig laucer/receiver).

Note subsea preservation and hydrotest fluids may be discharged after handling onboard the NY FPSO. See relevant sections.

Subsea Control Fluids

Subsea control fluid is used to control well-head valves remotely from the facility. Control fluid is supplied to valves via an open-loop system, designed to release control fluid during operation (e.g. upon valve actuation) up to ~2 m^3/day use across the subsea system. Subsea control fluid may also be discharged during IMR activities (e.g. leak detection and SCM change outs).

The subsea control fluid currently in use at the NY facility is HW443, which is water-based and has an OCNS rating of D with a substitution warning. The substitution warning is a result of the fluorescein dye, which is 150 ppm within the product. The dye is used to support leak detection and subsea IMR troubleshooting. The product does not pose a particularly high risk of ecotoxicity or bioaccumulation.

Hydrocarbons

Potential discharges associated with spool or subsea valve replacement activities are difficult to accurately determine without detailed engineering and activity specific planning which incorporates risk reduction and mitigation considerations. Notwithstanding, and for the purposes of the risk assessment, a potential release associated with MPP change-out may be approximately 350 L of hydrocarbon. IMR activities may also result in small gas releases associated with isolation testing and breaking into containment. During operations there is the potential for discharge of minor fugitive hydrocarbons (predominantly gas bubbles) from subsea equipment such as from umbilicals/control lines, well equipment, valves, and flowline and pipeline seals.

Chemicals

Chemicals may be introduced into subsea infrastructure during IMR activities. These chemicals are used and discharged intermittently in small volumes. Small quantities of chemicals may remain in the flushed infrastructure, which may be released to the environment after disconnection.

Operational chemicals may be introduced into subsea infrastructure and production stream, either as process or non process chemicals (e.g. corrosion inhibitors, biocides, scale inhibitors). The use of operational chemicals is restricted to what is needed to complete a required task. All operational (process and non-process) chemicals are selected in accordance with the requirements of the chemical selection process.

Where operational chemicals enter the production systems, there is potential for them to apportion to the water phase; however, this is normally managed by reinjection with the PW stream.

Impact Assessment

There is potential for slight, short-term localised decrease in water quality at discharge location and adverse effects on marine biota as a result of planned routine and non-routine hydrocarbon and chemical discharges. However, planned discharges of hydrocarbons and chemicals are infrequent and are minimised as far as practicable via flushing off the lines back to the facility. Discharge locations are either the subsea valves (subsea control fluid), disconnection points in subsea infrastructure or the NY FPSO.

Subsea Control Fluids

Subsea control fluids are discharged from subsea valves at or near the seabed in relatively small volumes. Once released, control fluids are expected to mix rapidly in the water column and become diluted.

Impacts from the release of subsea control fluids are localised to the immediate vicinity of the release location and will not have any lasting effect, based on:

- the relatively small volumes of discharges;
- the low sensitivity of the receiving environment; and
- the rapid dilution of the release.

Given the nature of the control fluid, the receiving environment and the potential for bioaccumulation, the potential impacts to fauna, sediments and water quality are considered minor. The potential for bioaccumulation in organisms or accumulation in sediments is considered negligible.

Hydrocarbons

The small quantities of hydrocarbons that may be released during operations and IMR activities that break containment are buoyant and will float towards the surface. Given the water depth, pressure, and the small volumes released, these hydrocarbons are not expected to reach the sea surface. Rather, the release will disperse and/or dissolve within the water column.

While recognising the potential ecotoxicity and physical effects of released hydrocarbons, the low release volumes for routine activities, dispersion and dissolution is expected to result in hydrocarbon contamination decreasing to background levels rapidly. As such, impacts from routine releases of hydrocarbons will have no lasting effect and are highly localised. Infrequent non-routine IMR activities with increased volumes discharged (e.g. MPP change-out) are not expected to result in impacts greater than slight, short-term localised decrease in water quality at discharge location.

Chemicals

Routine and non-routine discharges of chemicals are localised to the immediate vicinity of the release location and will not have any lasting effect. This is based on the:

- the relatively small volumes of discharges;
- low potential for toxicity and bioaccumulation;
- relatively small volumes of discharges;
- intermittent nature of the discharges;
- low sensitivity of the receiving environment; and
- rapid dilution of the release.

Summary of Control Measures

- Chemical Selection and Assessment Environment Guideline
    - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required; and

    - If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the procedure prior to use.
- Subsea infrastructure flushed where practicable during IMR disconnection activities; and
- Monitor subsea control fluid use, investigate material discrepancies, and use control fluid with dye marker to help identify potential integrity failures.

Non-Routine Discharges: Dewatering and Commissioning

Impacts Evaluation Summary													
Source of Risk / 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
Discharge of inhibited seawater during GE flowline dewatering.			X			X		A	E	-	-	LCS GP PJ	Broadly Acceptable
Discharge of well clean-up fluids and PW during commissioning of GE production wells.			X			X		A	E	-	-		
Discharge of PW and preservation fluids during Vincent re-commissioning.			X			X		A	E	-	-		
Description of Source of Impact													

Flowline dewatering, Vincent re-commissioning and GE well clean-up and commissioning are short-term activities which will result in a number of non-routine discharges such as PW, well clean up fluids and inhibited seawater. The discharges and a description of the source of risk are described below and summarised in **Table 12-4** and **Table 12-5**.

Vincent Recommissioning

During Vincent re-commissioning, biocide dosed PW (effluent reference A1 in **Table 12-4**) within the flowlines will be flowed to the facility, immediately followed by normal well fluids, including PW from the previously commissioned Vincent wells. Both streams will be processed through the FPSO's normal PW treatment process and water injection system during the Vincent re-commissioning phase. If the re-injection system is not available during this period, up to 50,000 m^3 (2,592 m^3/day for a maximum of 20 days) of PW may be processed to the temporary water treatment skid and discharged.

PW consists of formation water (derived from a water reservoir below the hydrocarbon formation) and condensed water (water vapour present within gas/condensate which condenses when brought to the surface). Separation of water from reservoir fluids is not 100% effective and separated water often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (aliphatic and aromatic hydrocarbons, organic acids and phenols), inorganic compounds (e.g. soluble inorganic chemicals, dissolved metals) and residual process chemicals.

Table 12-4: Planned commissioning discharges during RFSU 0

Stage	Ref	Effluent Source	Volume	Duration of discharge	Discharge location	Description of discharge
RFSU 0	A1	Vincent Flowline Dewatering	470 m^3	Up to 20 days	Treatment by Cetco skid and discharged to sea from FPSO.	Vincent PW with 300 ppm biocide.
RFSU 0	A_2	Vincent PW	2,592 m^3/day			Vincent PW

1 This is inclusive of A_1.

Flowline Dewatering and Commissioning of GE production wells

- **Table 12-5** summarises discharges to the environment that will occur during GE production well commissioning periods (RFSU 1 – RFSU 4). During start-up of the first GE well (RFSU1), up to 1,450 m^3 of inhibited sea water (B_1) will be discharged from the ILT Once this discharge is complete, the ILT will be closed and all remaining inhibited seawater (B_2) within the GE production flowline & associated subsea infrastructure (1,550- 1,750 m^3) will be flowed to the FPSO followed by normal production and well fluids. The remaining up to 200 m^3 of inhibited seawater within the GE infrastructure (B_3) (i.e. flexibles, jumpers) will be produced as the related well is brought online in later RFSU periods.
- Once the 16" pipeline is dewatered, the first fluids from the new GE wells to reach the FPSO will be completion fluids. Each well will contain approximately 25 m^3 of completion fluids (C_1), followed by hydrocarbons and PW.
- During well clean up, any PW brought to the facility from the new GE wells is expected to mainly consist of condensed water. PW from GE wells will comprise the majority of volume of water (~85%) discharged during each well clean up period. During well clean up, wells within the Vincent field will be produced through HP Separator A at minimum stable rates. Any PW from the Vincent field carried over to the LP separator during well clean ups will be directed to a common off-spec holding tank. In this tank, Vincent PW will co-mingle with water from the new GE wells and during the first few days of a well clean up, is not expected to be suitable for re-injection and will therefore be discharged through the temporary water treatment skid. During RFSU 1, three production wells are brought online sequentially so the period required for water to reach discharge specifications may be slightly longer than subsequent well clean ups, where wells are brought on one at a time.

All remaining GE production wells will be sequentially cleaned up as they are completed (RFSU 2 – 4) and during these periods the discharges described **Table 12-5** as B_3, C, D_1 and D_2 will occur. There are no discharges during RFSU 5. RFSU 1 will immediately follow RFSU 0. RFSU 2 – 4 will occur over a period of up to 9 months after RFSU 0.

Table 12-5: Discharges associated with GE Production Well Commissioning Periods (RFSU 1 – 4)

Stage	Ref	Effluent Source	Volume (Approximate)	Duration of discharge	Discharge Location	Description of discharge
RFSU1	B_1	GE 16" Flowline (Subsea between FPSO and ILT)	1,250 - 1,450 m^3	Discharged over approximately 24 hours.	To ocean at the CIM In Line Tee	Inhibited sea water as per

RFSU1	B_2	Remainder of fluids within GE 16” flowline.	1,550 – 1,750 m^3	Brought to FPSO over approximately 24 hours.	Discharged to sea from FPSO after treatment via Cetco water treatment skid.	Inhibited sea water as per & subsea production chemicals
RFSU 1 – 4	B_3	Fluids in infrastructure associated with that RFSU period (x-mas tree, flexibles etc).	100 m^3 – 200 m^3 per RFSU period	Intermittently as relevant well brought online.		
	C	Completion fluids	25 m^3 per well	Discharge takes less than 1 hour.		Low toxicity brine, filter cake, trace chemicals
	D_1	GE PW	2,200 m^3 per day	Up to 10 days during RFSU 1 Up to 6 days during each of RFSU 2,3 and 4. i.e. 28 days in total		Vincent and GE PW
	D_2	Vincent PW	300 m^3 per day			

Impact Assessment

Discharge of Inhibited Seawater during Flowline Dewatering

The impacts associated with dewatering of the subsea systems are outlined below. To understand the extent of impacts from these discharges, Woodside has used the results of analogous modelling. Woodside has previously commissioned modelling for a discharge of 1,449 m^3 of inhibited seawater, as part of the GWF Project (APASA, 2012). A comparison between the discharge parameters for the modelled scenario and flowline dewatering are shown in Table 12-6.

The key discharge parameters are shown in Table 12-6. Most key parameters show a high degree of similarity and/or are conservative for the GE dewatering case. In particular, the volume, chemical compositions and currents are very similar between the two cases. The GED discharge contains MEG, which wasn’t included in the modelled analogue, but the buoyant nature of MEG is expected to increase dilution in the water column and limit the horizontal extent of the plume compared to the modelled outcome. MEG is also PLONOR. The discharge of inhibited seawater at the CIM ILT will consist of chemicals. The majority of the discharge comprises natural seawater (74.2%) and MEG (25.6%) which is considered PLONOR. A dye and corrosion inhibitor has been added to the pipeline, equivalent to a final concentration of 50 ppm and 5 ppm respectively. Additionally, a combined oxygen scavenger/biocide, Hydrosure O3670-R is added at a concentration of 550 ppm.

To interpret model results and predict environmental impacts, it was necessary to understand the toxicity of the inhibited seawater discharge. LC50 data of 1 – 10 ppm was based on hydrosure MSDS data available at the time the modelling was originally conducted. LC 50 data for hydrosure was chosen to be conservative as it is the most toxic component of the discharge.

The modelling results, presented in **Table 12-7**, predicted that the plume would dilute to below 1 ppm at the edge of the near-field mixing zone. At this point, the the plume was predicted to extend to a maximum horizontal distance of approximately 47.3 m from the discharge location.

Table 12-6: Modelled and expected parameters of inhibited seawater discharge from CIM ILT

	APASA Modelling GWF - 1 (Wet Buckle)	Release at CIM ILT (B_1)
Discharge volume (m^3)	1,449	Up to 1,450
Duration (hours)	5	~24
Average flow rate (m^3/s)	0.0805	0.0161
Discharge Pipe Diameter (m)	0.1	0.05
Discharge Velocity (m/s)	9.95	1.99

Discharge orientation	Horizontal (Parallel to seabed)	Vertical (perpendicular to seabed)
Discharge depth	118	550
Current speed (m/s)	0.21 (mean)	0.20[1]
Water (sea) temperature (mean)	21	12[1]
Biocide concentration (Hydrosure) (ppm)	550	550
Dye concentration (ppm)	50	50
MEG concentration (%)	0	30

1 – Vincent – Basic Design data Specification Sheet – Metocean (DRIMS#9650826)
*See below for discussion on toxicity values of discharged fluids.

Table 12-7: Initial plume parameters at the end of near-field zone for the GWF-1 inhibited seawater discharge simulations (APASA 2012)

Temperature ◦ C	Flow rate (m/s)	Current speed (m/s)	Dilutions	Concentration (ppm)	Max horizontal distance of centre line from release (m)	Plume width (m)
19	0.0805	0.21	897	0.6	47.3	21.1

To determine the expected toxicity impacts of seawater a review of recent published information was undertaken. The review identified that Chevron (Chevron 2015) has conducted whole effluent toxicity testing for inhibited seawater dosed with 500 ppm of Hydrosure O3670-R and 50 ppm of dye. While the GED discharge also includes MEG and a corrosion inhibitor, these products are either PLONOR and dosed at very low concentration (5ppm) so are not expected to significantly increase product toxicity when compared with the Chevron test results.

Chevron 2015 found that the NOEC for the inhibited seawater mix, for the protection of 99% and 95% of species, to be 0.06 ppm and 0.1 ppm respectively. The modelling results in **Table 12-7** show that the dewatering of the GE flowline would achieve a concentration of 0.6 mg/L at a maximum distance of 47.3 m from the release point. Far-field modelling was not conducted, however, only an additional 10 dilutions are required to achieve the 99% species protection value. This is conservatively expected to occur no more than 100 m from the discharge point.

The shortest duration of the discharge is ~12 hours, with a maximum expected duration of 36 hours. Therefore the likelihood of fish or pelagic invertebrates being exposed to concentrations at these levels for greater than 48 hours (the threshold where chronic effects may occur) is negligible. Furthermore, it is expected that motile fish and other marine fauna will adapt their behaviour and move away from the discharge, if exposed. Impact on the surrounding seabed at the location of the discharge is expected to be minimal and localised to a small area (<100m) around the ILT discharge location.

The habitats in the vicinity of the proposed release location are mostly comprised of benthic communities typical of the NWMR and the seabed is qualitatively known from surveys pre and post-installation to be flat and featureless with no hard substrate habitat observed in the vicinity of the discharge location. Impacts on benthic communities are therefore predicted to be negligible due to the relatively low biological abundance and wide distribution of similar community types throughout the region. Potential impacts to infauna include short-term and localised impact to infauna populations with a temporary decline in abundance in the immediate area of the discharge, however, populations would recover rapidly by recolonisation by surrounding populations (Neff, 2005). The depth of the discharge location (550 m) mean there is no primary productivity occurring in the vicinity of the discharge location. Potential impacts to pelagic fish species and marine mammals are expected to be limited to avoidance of the localised area of the plume for a short duration.

Plankton populations may be affected in the immediate discharge plume; however, given the fast population turn-over of open water plankton populations, the potential ecological impacts are considered to be slight and short-term.

In relation to the discharge at the Cim ILT, no impacts to KEFs are expected as the discharge is located approximately 1,200 m from the continental slope demersal fish communities KEF and approximately 500 m from the Canyons KEF at the closest point (**Figure 12-1**) which is outside the predicted area of the plume.

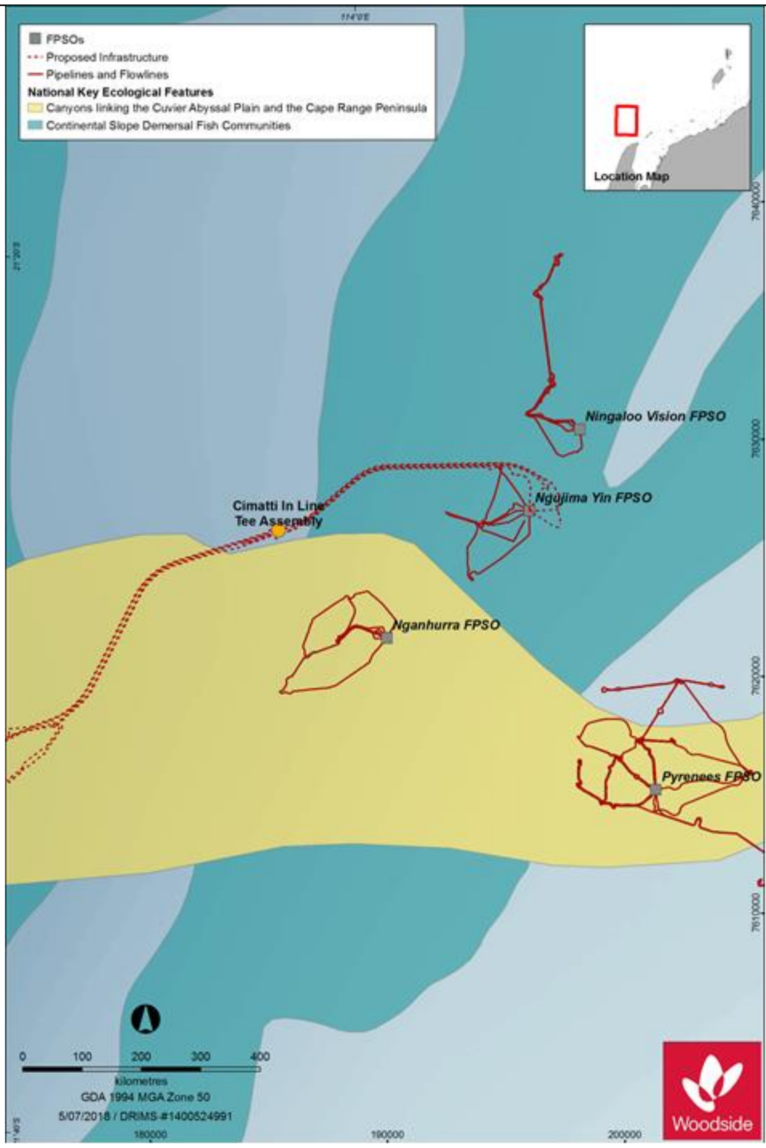

Figure 12-1:Location of the CIM ILT in relation to nearby Key Ecological Features.

Discharge of produced water during Vincent recommissioning

Based on the components of each of the commissioning discharges Vincent PW is expected to be the most toxic discharge. PW from GE will be similar to Vincent, but is primarily condensed water which is less toxic than formation water that is being produced from Vincent. Information on the toxicity of condensed water is provided below.

Due to the short duration of each individual commissioning discharges, and variation in composition of condensed water from different wells, there is no method of determining the toxicity of each individual discharge that could subsequently be used to inform management measures to reduce the potential impact of subsequent commissioning discharges. Therefore the impact of Vincent PW discharges is considered representative of the potential impacts from commissioning discharges excluding the discharge of inhibited seawater (B1).

Most treated PW has low to moderate toxicity (Neff et al. 2011), with actual toxicity of discharge dependant on the chemical constituents of the PW and any added process chemicals, the level of treatment and dilution with condensed water prior to release, and the dilution of the discharge as it mixes with sea water. Most hydrocarbons in PW are considered non-specific narcotic toxins with additive toxicities; therefore, the toxicity of a PW will, in part, depend on the total concentration and range of bioavailable hydrocarbons (Neff 2002). The toxicity of Vincent PW is known from recent whole effluent toxicity (WET) tests, which were undertaken in 2011 and 2014 **(Table 12-8**).

Table 12-8: PC95 and PC99 concentrations and safe dilutions (PNEC)

Species Protection Level	PNEC concentrations	
PCx	2011	2014

PC99 (50)	0.03% (1 in 3,300)	0.01% (1 in 10,000)
PC95 (50)	0.21% (1 in 480)	0.14% (1 in 710)

No WET testing data has been undertaken since 2014 (Jacobs 2015), however chemical characterisation and analysis of single species toxicity in 2016 determined that that PW toxicity had not significantly increased from previous years, and was comparable to the toxicity measured in 2014.

WET testing results presented in **Table 12-8** are considered to be representative of the toxicity of Vincent PW to be produced during RFSU 0 - 5 as no new wells producing formation water have been brought online and there have been no changes to the Vincent PW processing system that would increase toxicity.

Toxicity of condensed water

Condensed water from GE is expected have a toxicity that is equal to or less than that of Vincent PW. This is based on the following considerations:

1. Due to it's physical properties condensed water only interacts with reservoir (hydrocarbon) contaminants for short periods of time in comparison to formation water therefore is likely to be less toxic; and
2. A review of reservoir characteristics between GE and Vincent shows a high degree of similarity of hydrocarbon types and ratios; and
3. Samples of condensed (2011) and produced formation water (2014) from the Angel reservoir where the former demonstrates lower toxicity.

Physical properties

In this context, condensed water is pure water that condenses out of the gaseous phase due primarily to the reduction in temperature that occurs when reservoir fluids are brought to the surface (Veil et al 2004). It is distinguished from the formation water present in an oil and gas reservoir, which is in permanent contact with the reservoir geology (Bakke et al 2013). As it is pure water, condensed water does not bring additional contaminants to the surface, instead it acts as a solvent for contaminants during short transition through production system. Formation water, which is physically present in the liquid phase when present in hydrocarbon reservoirs and can therefore dissolve/entrain potential contaminants for millennia. Condensed water interacts with potential solutes (e.g. hydrocarbons, heavy metals) for hours or days. In particular, higher molecular weight hydrocarbons, which have low solubility in water (Pereda et al 2009) are typically found in occur in lower concentrations in condensed water than in the equivalent formation water.

Based on these properties, the toxicity of condensed water toxicity is expected to be equal to or less than that of formation water from the equivalent reservoir.

Similar Reservoir Characteristics

The expected composition of hydrocarbons within all reservoirs produced to the NY FPSO are described in the Greater Enfield Development Basis of Design Specification sheet (V000SB10169089), summarised in Table 12-9. The BOD states that the NOL and LAV oil and gas reservoirs are similar in quality and oil type to the Vincent Fields. The CIM oil field is more similar to the Enfield reservoir, but there is only a single GED well producing from this reservoir.

The ratio of composition of high solubility lower weight hydrocarbons that are most likely to be soluble in condensed water are similar between reservoirs. The relative proportion of main hydrocarbon groupings are outlined in the table below, showing the similarities between Vincent NOL and LAV wells. Condensed water from CIM will only occur for a maximum of 6 days.

Table 12-9: Relative abundance of difference hydrocarbon groups in Vincent and Greater Enfield reservoirs.

Vincent		Norton Over Laverda		Laverda Canyon		Cimatti	
C1 - C5	32%	C1-C6	39.57%	C1-C6	40.39%	C1 - C5	61.67%
C6 - C10	0%	C6-C10	0.02%	C6-C9	0.16%	C6 - C9	7%
C10-16	14%	C9-15	11.26%	C9-15	10.95%	C10-15	13.05%
C16-19	13%	C15-17	9.22%	C16-17	8.97%	C16-19	5.60%
C19-22	10%	C17-20	10.68%	C18-20	10.38%	C20-24	5.54%
C22-26	9%	C20-25	10.71%	C21-25	10.42%	C24+	5.44%
C26-34	11%	C25-32	9.19%	C26-32	8.94%		
C34+	10%	C32+	9.03%	C32+	8.78%		

Toxicity of Angel condensed and formation water.

The Woodside operated Angel Platform is located on the North West Shelf, producing condensate and gas from a single reservoir via three operating wells. The Angel gas field is a swing producer: i.e. wells are produced only when required to fill onshore demand. Woodside has conducted produced water toxicity assessments from Angel on two occasions where the facility was discharging only condensed water (2011) followed by a scenario where primarily formation water was being discharged (2014). A key indicator for the type of PW being discharged is the salinity, which in 2011 was 0 ppt and in 2014 was 23 ppt (Jacobs 2015).

The Angel water (condensed/produced water) sampled in 2014 (Jacobs 2015) showed higher rates of low solubility hydrocarbons, phenols and certain heavy metals (e.g. zinc, manganese, mercury), consistent with the expected physical properties of produced formation water. The samples also showed a higher level of toxicity than 2011 samples (**Table 12-10**).

This analysis is further supported by reviewing toxicity data from the PW discharged from the NRC and GWA Platforms. NRC only discharges condensed water, and toxicity data has consistently been significantly lower than that from the nearby GWA, which has a similar processing system and similar reservoir composition and discharges produced formation water.

Table 12-10: Guideline values (estimated safe dilutions) for Angel in 2011 and 2014 (adapted from Jacobs 2015).

PCx	2011	2014
PX99 (50)	0.38 (1 in 260)	0.053 (1 in 1900)
PC95 (50)	0.53 (in in 190)	0.35 (1 in 290)

Determination of mixing zone of commissioning discharges.

Modelling of the rate of dilutions achieved via discharges from the NY FPSO to the overboard caisson have most recently been conducted in 2014 (Jacobs 2015). The modelling included a PW flow scenario of 2,592 m^3/day.

Using these NY WET testing results, the modelling shows that dilution to achieve 95% species protection would still be achieved within 30m of the discharge point in the worst case scenario. In addition, a high level (99% species protection) of environmental protection is achieved within 1,500 m (**Table 12-11**). The buoyant nature of the plume indicates toxicity of the plume does not extend below 10 m in depth (Jacobs 2015).

Table 12-11: Maximum modelled distances at which 95% and 99% species protection trigger values are achieved from the discharge point

Discharge Rate (m^3/d)	Toxicity Assumption	PNEC 99%	PNEC 95%	Max Dist to PEC=PNEC (m) (99%)			Max Dist to PEC=PNEC (m) (95%)		
				Winter	Summer	Transition	Winter	Summer	Transition
2,592	2014 Toxicity	0.01	0.14	1,500	1,100	600	<20	30	30

Chemical Characterisation of Vincent PW (Physio-chemical Parameters)

The chemical characteristics of Vincent PW is known from sampling of undiluted Vincent PFW undertaken in 2011, 2014, 2015 and 2016. Physio-chemical characteristics are presented in **Table 12-12** and heavy metal and major ions in the PW are presented in **Table 12-13** and compared with ANZECC/ARMCANZ 99% species protection guideline values.

The contaminant with the highest concentration above 99% species protection levels, ammonia, requires ~45 dilutions to achieve safe levels. Modelling conducted for the NY FPSO indicates this level of dilution would be achieved within 30 m of the facility in all seasonal conditions. As Vincent PW is representative of Vincent PW produced during commissioning 99% species protection values are likely to be achieved within a short distance of the FPSO.

Table 12-12 Chemical characterisation within NY PW during recent chemical characterisation events

Analyte	Ngujima-Yin				
	ANZECC trigger value (µg/L) [a]	2011	2014	2015	2016
pH		6.5	6.6	6.5	6.7
Salinity (%)		36	35	38	35
Conductivity (ms/Cm)		56	53	57	53

Dissolved Oxygen (%)		35	37	40	28
Ammonia (NH_3-N mg/L)	0.5	23	24	26	21
Total Organic Carbon (TOC) (mg/L)		19	6.8	210	3.7
Dissolved Organic Carbon (DOC) (mg/L)		-	5.9	200	3.3
Biological Oxygen Demand (BOD) (mg/L)		-	7	250	<4
Total Dissolved Solids (TDS) (mg/L)		-	36,000	23,000	33,000
Total Suspended Solids (TSS) (mg/L)		-	20	38	12
Total Sulphide (mg/L)		-	0.26	0.22	0.05

[a] 99% species protection guideline value (ANZECC/ARMCANZ 2009) guideline ranking of moderate and high reliability is shown in parenthesis **

Table 12-13 Total and Dissolved metals within NY PW during recent chemical characterisation events

Metals (µg/L)	ANZECC trigger value (µg/L) [a]	Ngujima-Yin (NY)							
		2011		2014		2015		2016	
		Diss	Total	Diss	Total	Diss	Total	Diss	Total
Silver	0.8 (high)	<5	<5	<0.2	<0.2	<0.2	<0.2	0.05	0.03
Aluminium	24[d]	-	-	14	11	1	13	7	12
Arsenic	[f]	<0.2	0.2	-	-	-	-	-	-
Barium	[c]	12,200	12,200	8,200	11,300	10,500	10,900	11,000	11,000
Cadmium	0.7 (high)	<0.1	<0.1	0.03	0.11	<0.02	<0.02	0.03	<0.02
Cobalt	0.005 (high)	-	-	0.14	0.18	0.4	0.5	0.04	0.03
Chromium	7.7 (III) (moderate 0.14 (V) (high)	<1	1	<1	<1	1	1	0.7	1.1
Copper	0.3 (high)	<1	<1	0.8	1.8	1.4	3	0.1	0.35
Iron	[c]	436	1,500	2,900	3,000	2,700	2,800	1,500	1,600
Manganese	140[e]	436	433	536	536	736	729	524	541
Nickel	7(high)	<1	<1	1	1.4	3.7	4.1	0.6	0.5
Lead	2.2 (high)	<0.5	<0.5	0.1	0.1	<1	<1	<0.03	<0.03
Zinc	7 (high)	<3	<3	72	1,170	39	123	3	5
Mercury	0.1 (high)	-	<0.01	-	0.0014	-	0.03	-	0.0008

[a] 99% species protection guideline value (ANZECC/ARMCANZ 2009) guideline ranking of moderate and high reliability is shown in parenthesis.
[b] Dissolved fraction (0.45 µg/L).
[c] No guideline value.
[d] Golding et al. (2015) and draft submission paper to the Council of Australian Government's Standing Council on Environment and Water (SCEW).
[e] Draft submission paper to the Council of Australian Government's Standing Council on Environment and Water (SCEW 2014).
[f] Low reliability guideline trigger values have been derived in the absence of a data set of sufficient quantity, using larger assessment factors to account for greater uncertainty. Values are not used as default guidelines but are compared with PW characterisation values.

Further assessment of Commissioning Discharge Toxicity

With the controls implemented for the commissioning discharges and based on a review of the range of observed toxicity from PW discharges at Woodside operated facilities, it is not considered credible that the impact of discharges could exceed a slight, short term impact. The highest observed toxicity from any Woodside operated facility was experienced at the Nganhurra, which required 1,300 dilutions to achieve a 95% species protection value. Given the well mixed waters at the Exmouth plateau, this level of protection continued to be achieved within 100 m of the facility at the highest forecast discharge rates (Jacobs 2015). The Woodside Environmental Performance standard requires all discharges to be dilute to achieve a 95% species protection by 500 m of any discharge.

While it may not be possible to establish an exact mixing zone for commissioning discharges, controlling the key sources of environmental harm through the implementation of selected controls will reduce the impact of discharges of this nature to slight and will be temporary in nature.

Bio-accumulation

Bioaccumulation refers to the amount of a substance taken up by an organism through all routes of exposure (water, diet, inhalation, epidermal). There is little potential for bioaccumulation in the environment from commissioning discharges, given the short duration of each commissioning discharge event, low volume of discharge, non-continuous nature of the discharge and nature of the effluent.

The potential environmental impact associated with bioaccumulation of commissioning discharges constituents in the water column is considered to be limited to a potential localised effect on a small number of non-threatened species in waters immediately surrounding the facility.

Sediment impacts

Inhibited seawater, completion fluids and condensed water do not contain any components which would result in potentially toxic sediment impacts. Constituents within PW can potentially cause impacts to surrounding sediments if released in sufficient quantity of are of a nature that can accumulate on the sea floor.

Accumulation of contaminants in sediments depends primarily on the volume/concentration of particulates in effluent discharges or constituents that sorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and re-suspension, bioturbation and microbial decay of those particulates in the water column and on the seabed. Woodside has previously assessed the risk of any given discharged particle settling to the seabed.

Treatment of commissioning discharges through a temporary water treatment skid is designed to limit the size of discharged particles to 20 µm or less, this significantly limits the size and volume of particles being discharged to the environment. Therefore it is unlikely that any small particles within the commissioning discharges, or formed by mixing with seawater, would settle out of the water column in the vicinity of a facility discharging PW where oceanographic conditions are dynamic. Given the short duration, intermittent nature of discharges and significant water depth at the facility, the potential for particles to settle and accumulate to levels which pose a risk to the receiving environment (i.e. that required to exceed ISQG's) is not credible.

Potential impacts to Key Ecological Features

The PW discharge zone overlaps a portion the Continental Slope Demersal Fish communities KEF. Given the large spatial area of the KEF, the minimal area of the KEF intersected by the discharge zone and temporary nature of the PW discharge, impacts to the KEF are expected to be slight and short term in nature. As the discharge plume is buoyant and 95% species protection is achieved within 100 m in any direction of the discharge, the seabed is unlikely to be contacted by the plume and if contact occurs, water would have achieved the 95% species protection level before contact occurs. Demersal fish are unlikely to be impacted, directly or through habitat exclusion, by this contact.

Potential impacts to EPBC Act Listed Species

EPBC Act listed species may occur within the Operational Area where the commissioning discharges occur. Key threats identified in species recovery plans and conservation advices and corresponding conservation actions are outlined in the EP. Chemical and terrestrial discharges are identified as a potential threat to according to the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017) (the Recovery Plan).

Given the absence of potential nesting or foraging habitat for turtles (i.e. no emergent islands, reef habitat or shallow shoals) and the water depth, (340-849 m) large numbers of marine turtles are unlikely to be found in the Operational Area. The outer portion of a critical nesting habitat for flatback turtles identified in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017) overlaps the Operational Area; however, marine turtles (including flatback turtles) are considered unlikely to be present due to the distance from shore (38 km from Murion

Islands) and water depth. Flatbacks also spend the internesting period off the east coast of Barrow Island, and also in shallow nearshore waters off the adjacent mainland (Chevron Australia, 2015; Pendoley, 2005; Whittock, Pendoley, Hamann, 2014).

Given the short-term nature of the commissioning discharges and that turtles are unlikely to be encountered in the Operational Area, impacts to biologically important behaviour of turtles are unlikely and minimisation of discharges is not required.

The pygmy blue whale migration BIA also overlaps the Operational Area. Discharges are identified as a key threat in the Conservation management plan for the blue whale: A recovery plan under the EPBC Act 1999 2015-2025 (Commonwealth of Australia 2015). Pygmy blue whale may transit the Operational Area between October to December (northbound migration) and April to August (southbound migration) (McCauley and Jenner 2010). Pygmy blue whales were not recorded in a series of whale monitoring flights between July and September (RPS Environment and Planning 2010a), although these flights were intended to record humpback whales and did not extensively sample deeper waters preferred by pygmy blue whales. Observations of whales by personnel onboard the NY FPSO have not confirmed the presence of pygmy blue whales in the Operational Area. Given the short-term nature of the commissioning discharges, the seasonality of humpback whales in the Operational Area, and low density of pygmy blue whales recorded in the Operational Area, impacts to pygmy blue whales are unlikely.

Cumulative Impacts

The extent of commissioning discharges, as shown by estimation of the maximum extent of the potential mixing zone show no potential interaction with other discharges in the region. Commissioning discharges may interact with the other main discharge from the FPSO which are from the seawater cooling caisson, as per Section 5.6.5. However, the location of the discharges on the FPSO are more than 100 m apart, meaning commissioning discharges would be at least safe to 95% of species and cooling water would be only slightly above ambient temperatures when any contact occurred.

Given that impacts on water quality and marine biota commissioning discharges are predicted to be slight and short term, cumulative impacts on such environmental values are considered unlikely, particularly due to the lack of environmental sensitivities within the direct vicinity of the proposed discharge locations and short, non-continuous nature of the discharges.

Summary

There is potential for slight, short-term water quality impacts and adverse effects on marine biota as a result of the commissioning discharges. Modelling indicates that given the low daily discharge volume and rapid dilution open water offshore environment, any impacts are expected to be confined to the immediate vicinity of the FPSO. In the context of the life of the asset, discharges will occur for a relatively short period and longer term impacts, such as bio-accumulation, or benthic habitat impacts through sedimentation are not predicted to occur. Impacts may include short-term, localised decline in planktonic organisms, which will recover rapidly once the discharge ceases. No impacts to fauna such as fish, turtles, cetaceans or birds are expected to occur.

This results in an assessment that so long as controls pertaining to the minimisation of OIW levels, solids contents, discharge volumes and discharge durations the impacts from the temporary commissioning discharges will be Slight (E) and short-term over the duration of the Petroleum Activities Program.

Summary of Control Measures

- Chemical Selection and Assessment Environment Guideline:
  - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required; and
  - If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the procedure prior to use.
- Monitoring and management of OIW concentrations in accordance with PARCOM 1997/16 Annex 3 methodology:
  - Commissioning discharges treated through a temporary water treatment system so that OIW is limited to a 30 mg/L 24-hour rolling average.
- Procedural controls in place to monitor and control discharge volume and OIW concentrations, and prevent discharges with high OIW concentrations.
  - Monitoring of OIW using an online OIW concentration analyser or manual sampling.
- Process performance monitoring equipment installed as part of the temporary water treatment skid calibrated and maintained.
- Limit the total duration of days on which commissioning discharges will occur to no more than 50.
- Inclusion of solids filter (20 micron) as part of the temporary water treatment package.
- Re-inject Vincent PW whenever practicable during Vincent re-commissioning (RFSU-0).

Routine and Non-Routine Discharges: Discharges from Utility Systems and Drains

Impacts 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/Impact		Likelihood	Risk Rating	ALARP Tools	Acceptability
Discharge of sewage, grey water and putrescible waste from NY FPSO and vessels to the marine environment.			X					A	F	Cumulative E	-	-	LCS GP PJ	Broadly Acceptable
Discharge of deck water from NY FPSO and bilge water from vessels to the marine environment.			X					A	F		-	-		
Discharge of brine from vessels and NY FPSO to the marine environment.			X					A	F		-	-		
Discharge of CWF CIP effluent from NY FPSO.			X					A	E		-	-		
Discharge of seawater systems (including cooling water) from NY FPSO and vessels to the marine environment.			X					A	F		-	-		

Description of Source of Impact

Sewage, Putrescible Waste and Grey Water

Sewage and grey-water is treated onboard the NY facility by a biological sewage treatment plant, which includes maceration, biological treatment and disinfection. The treatment process is consistent with secondary sewage treatment and the requirements of IMO Marine Protection Environment Committee 2 (VI) criteria. The sewage treatment plant onboard the NY FPSO is capable of handling inputs from up to 80 PoB, which is adequate for routine and non-routine personnel levels onboard the FPSO. Sewage treatment onboard facility support and subsea vessels will vary. Treatment systems may require routine maintenance or repair during operations, which may necessitate infrequent, short periods in which sewage is directly discharged overboard.

Putrescible wastes (e.g. food scraps) from the NY FPSO and vessels may be macerated prior to being discharged overboard. Putrescible wastes may also be retained onboard and disposed onshore.

The volume of sewage, grey-water and putrescible waste generated is estimated to be in the order of 6 m^3 per day (based on an average volume of 75 L/person/day). The actual volume of discharge will vary depending on personnel levels on the NY FPSO and vessels. Discharge of treated sewage and grey water from the NY FPSO is directly to the sea via a pipe below the sea surface. Discharge locations from vessels may vary but are typically at or near the water surface.

Slops, Drain and Bilge Water

Operational non-process discharges, process maintenance drainage and flushing discharges, washdown water and potential spills are contained in the non-hazardous and hazardous open drain systems onboard the NY FPSO. These systems drain to the slops tank and do not drain to the environment. Machinery space bilges on the NY FPSO also drain to the slops tank.

Chemicals used onboard the NY FPSO may be introduced to the drains system, including;

- Deck washdown, maintenance drainage of treated water systems (e.g. tempered water), and other cleaning/flushing activities.

- Mandatory annual testing of the active fire deluge and foam system for safety requirements.
- Marine growth treatment of drain caissons.

Mandatory testing of the active fire deluge and foam system onboard the FPSO is undertaken for safety requirements. This discharge is directed overboard to prevent foam contamination of the slops tank (which would decrease the effectiveness of gravity separation of hydrocarbons). Rainwater on the FPSO is also directed overboard instead of to the slops tanks.

Vessels routinely generate and discharge relatively small volumes of bilge water. Bilge tanks receive fluids from many parts of the vessel, including machinery spaces. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals. Water sources could include rainfall events and/or deck activities such as cleaning/wash-down of equipment/decks.

A one off requirement to conduct stagger testing with sea water during RFSU 0, where this is typically performed with cargo. In the event this testing is conducted with sea water, the tank would have first been cleaned and certified as being oil free. The volume of water used in this testing is greater than can be re-injected and therefore would be discharged overboard.

Brine

The RO and distillation plants onboard the NY FPSO are used to produce potable water, with the brine produced discharged to the marine environment at the FPSO. Brine is generally 55–60 parts per thousand salt, with up to approximately 100 m^3 of brine produced per day. Small quantities of anti-scaling and cleaning chemicals may also be discharged with the brine. Small quantities of reverse osmosis (RO) brine may be generated by support or subsea vessels.

CWF Effluent

The CWF intakes seawater via the topsides seawater system, which is treated and injected to enhance hydrocarbon production. The CWF system is expected to generate approximately 4,300 m^3/day of routine process effluent. The effluent contains concentrated sulphates, calcium and magnesium that occur naturally in seawater, as well as a scale inhibitor. For short durations, the effluent will contain small concentrations of either sodium hypochlorite or biocide. The routine discharge stream is at ambient temperature and is routed to the existing seawater disposal caisson where the stream is diluted with the seawater cooling reject stream by approximately 18 times, before being discharged to the marine environment.

Non routine discharges from the CWF package, may include up to 20 m^3 of freshwater dosed with either citric acid or sodium carbonate, or fluids used to preserve the system when not in use, which comprises 65 m^3 of sea-water dosed with sodium bi-sulphate. These chemicals are considered PLONOR. The primary disposal route for these discharges is to the slops tanks, with their fate being reinjection into the disposal reservoir. Due to operational reasons, it may not be possible to direct these non routine discharges to the slops for reinjection from time to time In this case the non routine discharge may be overboarded via the existing seawater disposal caisson.

During start-up, turndown operation and injection well testing operations, there is also continuous overboarding of the filtrated CWF stream via pump minimum flows and SRU product dump lines, which includes residual oxygen scavenger and may include anti-foam

Seawater Systems Flow (including Cooling Water)

The seawater systems are routinely used onboard the NY FPSO for process and machinery cooling, which is returned to the sea via the seawater disposal caisson or marine sea chests. Seawater used for cooling, is dosed with copper ions to inhibit marine growth. The average discharge rate of sea water from the topsides cooling system and hull seawater cooling systems are approximately 80,000 m^3/day and 56,000 m^3/day respectively. Seawater discharge temperature from both systems is, on average, approximately 20°C above ambient seawater temperature (approximately 23°C), with a maximum discharge temperature of 55°C. As the discharge from the topsides cooling water system is a continuous production discharge and discharge from the hull seawater cooling system is intermittent, the impact assessment is based on the 80,000 m^3/day discharge from the topsides cooling water system.

Impact Assessment

Sewage, Putrescible Waste and Grey Water

The main environmental impact associated with ocean disposal of sewage, grey water and 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. Environmental receptors that may be exposed to sewage, grey water and putrescible waste discharges include plankton, marine reptiles, marine mammals and pelagic fish.

No significant impacts from the planned (routine and non-routine) discharges to environmental receptors 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 Operational Area. Water quality monitoring in the mixing zone around the NY FPSO indicated nutrients (e.g. ammonia, total nitrogen (TN) and total phosphorous (TP)) are consistent with background levels within 200 m of the discharge location (BMT Oceanica 2015a). This is consistent with other studies monitoring sewage discharges, which have demonstrated that a 10 m^3 sewage discharge reduced to approximately

1% of its original concentration within 50 m of the discharge location (Woodside, 2008).

The Operational Area is located more than 12 nm from land.

Vessels are typically moving when in the Operational Area, which facilitates the mixing of sewage, putrescible wastes and grey water from vessels.

The impact of nutrients associated with discharge of sewage, grey-water and putrescible waste is considered to have a localised impact, with no lasting effect due to the discharge mass and the assimilative capacity of the receiving environment.

Drain and Bilge Water

The slops tank receives drainage water from a range of sources, including:

- NY FPSO drain systems; and
- CWF periodic cleaning/maintenance effluent.

Slops tank water may contain small quantities of dissolved and residual hydrocarbons, and other chemicals such as detergents and cleaning agents. Given slops tank water is reinjected during normal operations, no impacts from slops tank water will occur.

Water foaming agents used in fire fighting foam may be harmful to aquatic organisms within freshwater environments like ponds and streams. This effect of the chemical release is greatly diminished in the offshore environment (due to wave and wind action) and does not present the same risks to pelagic fish and other marine life as is rapidly dispersed. Nevertheless, the planned release of these materials is restricted to testing activities and using the minimum amount required to ensure safe and effective operation of the system in an emergency.

Stagger test water will be clean seawater and the discharge will have no environmental impact.

RO Brine

Sodium hypochlorite and other chemicals within the RO brine stream are expected to readily dissociate and break down once discharged into the environment. Monitoring at other Woodside facilities with comparable water discharges did not indicate the pH within the mixing zone differs from the surrounding environment (BMT Oceanica 2015b); given sodium hypochlorite is basic, the monitoring suggests that sodium hypochlorite concentrations diminish rapidly following discharge. Other chemicals in these discharges, such as biocides and scale inhibitors, are expected to occur at low concentrations and mix rapidly.
Brine plumes discharged from the RO plant may result in osmotic stress to marine biota that rely on gills or diffusion across cell membranes to maintain osmotic pressure within cells. Mobile fauna such as fish may move away from the brine plume; hence impacts are restricted to planktonic and sessile organisms.

Once discharged into the marine environment, the brine plume is expected to sink due to its relatively high density. Sinking of the plume will facilitate turbulent mixing, as will surface currents and waves. Recent water quality monitoring at the NY FPSO indicated the brine plume mixed rapidly once released, and was not readily detectable within 50 m of the discharge location (the seawater disposal caisson) (BMT Oceanica 2015a). On this basis, the RO brine plume is expected to mix rapidly. Impacts from RO brine discharge will have no lasting effects on the environment and are highly localised to the discharge location.

CWF Effluent

The main environmental impact associated with disposal of CWF is reduction in water quality. The routine CWF discharge stream is at ambient seawater temperature therefore no impacts from temperature are anticipated. The concentrated sulphates, calcium and magnesium in the effluent, which occur naturally in seawater, are not considered contaminants of concern and are not anticipated to have any impacts. Additives to the CWF discharge stream are either naturally occurring in seawater (and therefore soluble in seawater) or are low toxicity, water soluble chemicals dosed at low rates.

The CWF discharge stream is expected to readily dilute by co-mingling with the cooling water discharge stream, by approximately 18 times prior to discharge. No credible impacts from the planned (routine and non-routine) discharges to environmental receptors are anticipated because of the minor quantities involved, low toxicity, the expected localised mixing zone, and high level of dilution into the open water marine environment of the Operational Area.

Seawater Systems Flow (including Cooling Water)

The main environmental impacts is temperature change potentially affecting open water receptors (fish and plankton populations). Elevated seawater temperatures may cause a variety of effects on both fish and plankton, ranging from behavioural response (including attraction and avoidance behaviour) and minor stress for prolonged exposure. Fish are unlikely to be impacted by the elevated temperatures other than through behavioural changes (avoidance and attraction). While impacts to plankton may include mortality, given the rapid turnover of plankton communities and mixing of adjacent populations, populations are expected to recover rapidly once discharge ceases.

Discharged cooling water (typically 80,000 m^3/day) is typically 20°C warmer than the ambient seawater. Given higher temperature, cooling water is expected to be buoyant compared to the receiving seawater and form a plume in near-surface waters down-current from the seawater disposal caisson.

Modelling of a similar discharge rate, of cooling water was previously conducted for the proposed Browse Upstream LNG Development (DHI, 2011) using Cornell Mixing Zone Expert System (CORMIX 6.0). This modelling assumed a cooling water discharge rate of 90,000 m^3/day at a temperature of 45°C at 20 m depth through a 1.2 m downwardfacing caisson which is comparable to the discharge of topsides cooling water (largest discharge from the FPSO) (**Table 12-14**). Based on a review of current speeds in the Exmouth basin metocean conditions are expected to be similar, with typical currents speeds of ~0.2 m/s (measured speeds ranged from 0.005 m/s to 0.52 m/s). Therefore, the modelling is representative of below sea surface cooling water discharges expected from the FPSO cooling water.

Table 12-14: Modelling results from Browse development and NRC cooling water discharge and the characteristics of the cooling water discharges from the NY FPSO

	Browse Modelling	NY Topside system	NRC Modelling
Flow rate (m^3/day)	90,000	80,000	295,200
Pipe diameter (m)	1.2	1.2	1.6 (per caisson)
Port exit velocity	0.92	0.72	-
Caisson elevation (m below surface)	-20	-5	-15
Excess salinity	0	0	0
Excess temperature	+19 (absolute 45)	+20 (absolute 55)	45
Ambient temperatures	28 (based on range of 26-30)	23 to 30	19 to 30
Ambient salinity	34.2	35.2 – 35.7	34

The Browse model found that under varying set tidal current speeds the thermal plume cooled to within 3°C of ambient within a short distance from the caisson. Using worse case (0.1 m/s) and typical current speeds (0.22 m/s) the thermal plume cooled to 3°C of ambient, within 15 m and 8 m of the discharge caisson respectively. These model results indicate that the temperature of topsides cooling water discharge plume would be reduced to less than 3°C above ambient within those same distances. As described previously, the cooling water discharge rate is typically of 80,000 m^3/day, which is less than the 90,000 m^3 discharge rate modelled. The lower volumes result in more effective near-field dilution reducing the distance required to achieve dilution to ambient temperatures.

Modelling was also undertaken for 295,200 to 405,600 m^3/day of cooling water (discharged from two discharged points) at NRC (SKM 2008). Given the two discharges from the FPSO combined (80,000 m^3/day and 56,000 m^3/day) are much smaller than the lower end of rates modelled at NRC this modelling is considered conservative. The NRC modelling found that under varying set tidal current speeds the thermal plume cooled to within 3°C of ambient within 200 m from the caisson. These model results support the assessment that the temperature of the combined topsides and hull seawater cooling system based cooling water discharge plumes would be reduced to less than 3°C above ambient well within 200 m. Based on current facility design, it is not possible to significantly increase the throughput of cooling water or the discharge temperature without significant equipment and process changes. Therefore, any increase in cooling water discharge rates or temperature beyond those considered above are not considered credible.

Water quality monitoring in the mixing zone around the NY FPSO could not detect elevated temperatures (SKM, 2010), indicating that temperatures returned to ambient within 10 m of the discharge point which is consistent with modelling. No significant impacts from the planned discharges to environmental receptors are anticipated because of the localised mixing zone, and high level of dilution into the open water marine environment.

The only additive to the seawater used in the seawater and cooling water systems is copper ions, which are generated to suppress growth of fouling organisms. Most copper ions will react and be neutralised within the cooling water system. Levels of copper from anti-biofouling systems have been measured by the US Uniform National Discharge Standards (UNDS) Program. Their research has shown that the concentration of copper discharged from antibiofouling systems is between 0.52 and 0.69 ppb (µg/L). In these low concentrations and on discharge into the marine environment, two or three dilutions are required to reduce residual copper concentration below ANZECC/Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guideline values (99% species protection trigger level for copper is 0.3 µg/L). At these low concentrations, copper is rapidly diluted to ambient background levels on discharge into the marine environment. Copper is an essential trace nutrient, and marine organisms (including mammals, fish, molluscs and crustaceans) have evolved mechanisms to regulate concentrations of free copper ions in their tissue received from ambient water, sediment or food (Neff 2002). These mechanisms are able to continue to operate, and only break down when copper concentrations reach near-lethal concentrations (Neff 2002). The discharge of copper ions in cooling water is not expected to result in significant bioaccumulation effects. The level of copper ions generated is controlled by the design of the system and anticipated to have no lasting effects on the environment and are highly localised to the discharge location.

Cumulative Impacts

Given the activities that may be conducted during the Petroleum Activities Program, there is the potential for cumulative impacts from routine discharges of sewage, putrescible waste, grey water, bilge water, drain water, cooling water and brine due to:

- Repeated / ongoing discharges at the same location (NY FPSO) over the course of the Petroleum Activities

Program; and

- Cumulative discharges from differing point sources (NY FPSO and vessels).

Given the nature of these routine discharges, the localised spatial extent of impacts and the well mixed receiving environment, the cumulative impacts from these discharges are not considered to result in impacts more than Slight short-term impact. Given the highly localised nature of the impacts of routine discharges, no cumulative impacts from similar discharges from other production facilities (e.g. Nganhurra and Ningaloo Vision FPSOs) will occur.

Summary of Control Measures

- NY FPSO and contract vessels compliant with Marine Orders for safe vessel operations:
    - Marine Orders 91 (Oil)
    - Marine Orders 95 (Pollution prevention – Garbage)
    - Marine Orders 96 (Pollution prevention – Sewage).
- Chemical Selection and Assessment Environment Guideline.
    - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required; and
    - If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the procedure prior to use.
- Putrescible waste from NY FPSO macerated prior to overboard discharge.
- Routine reinjection of slops tank water to prevent over boarding other than during re-commissioning and well clean up
- Facility process area drain systems maintained to return routine drain flows inboard to slops
- Sewage from NY FPSO processed by sewage treatment plant prior to discharge
- Reassess impact of cooling water discharge if significant equipment and/or process changes occur on the facility, with the potential to increase volume or temperature.

Routine and Non-Routine Atmospheric Emissions: Fuel Combustion, Flaring and Fugitives

Impacts Evaluation Summary													
Source of Risk / 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/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
NY FPSO and vessel fuel combustion emissions, NY FPSO operational flaring and fugitive emissions				X				A	F	-	-	LCS GP PJ	Broadly Acceptable
Description of Source of Impact													

Atmospheric emissions are generated from the NY FPSO and support vessels during the Petroleum Activities Program. Sources include emissions from internal combustion engines (including all equipment and generators), flares, fugitives and process vents. Vessel emissions include those from internal combustion engines, fugitives and onboard incinerators. Emissions and combustion products will typically include CO_2, water vapour, NOx, SO_2, methane, refrigerant gases (including ozone depleting substances), particulates and Volatile Organic Compounds (VOCs).

Fuel Emissions: Internal Combustion Engines and Waste Incinerators

Fuel gas consumption for compression and power generation is the predominant source of combustion emissions from the NY FPSO, primarily the three 12,500 kW gas turbine generators, the CWF turbine generator and high pressure reinjection compressor. The turbines may run on fuel gas or diesel. Emergency diesel generators may also be used when required.

Diesel is used for firewater pumps, emergency generators, cranes and back-up fuel for the turbine generators. The main engines on the NY FPSO also use diesel fuel. In 2016–1017, 85,347,297 Sm^3 of fuel gas was used, the combustion of which equated to the emission of 172,839 tonnes of CO_2 equivalents. Diesel usage on the facility (excluding support vessels) in 2016–2017 was 4665 Sm^3, the combustion of which equated to the emission 12,641 tonnes of CO_2 equivalents.

The forecast annual emissions from fuel combustion on the NY FPSO has been estimated using emissions factors (as per NPI EET) and are presented in Table 12-15.

Incinerators may be used onboard vessels to dispose of flammable domestic wastes such as cardboard. Incinerators are typically used infrequently, with wastes generally segregated and transported to shore for disposal.

Table 12-15: Estimated Annual Emissions from Fuel Combustion (based on FY2016/17)

Emission Type	Estimated annual emissions from fuel gas combustion (tonnes) [1]	Estimated annual emissions from diesel combustion (tonnes) [2]	Estimated total annual emissions from fuel combustion (tonnes)
CO_2	238,875	12,587	251,462
CH_4	464	0.72	465
N_2O	139	0.12	139
Total CO_2eq	238,875	12,641	251,516
NO_x	954	245	1,199
SO_x	1.5	0.08	2

Operational Flaring

The primary method for disposing produced gas is reinjection, with some gas used onboard as fuel gas. A relatively small volume of gas is used to maintain the flare during production. Flaring will also be used to dispose excess hydrocarbons during process upsets and well start-ups. Gas flaring has the potential to increase the volumes of greenhouse gases emitted to the atmosphere. Flaring will also consume natural gas, a non-renewable resource. Incomplete combustion, under certain scenarios, may also generate dark smoke.

The release of hydrocarbon gas combustion products to the atmosphere by flaring is an essential practice, primarily for safety requirements. Operational flaring comprises two elements:

- normal operational flaring associated with flare system purge, pilot and process flows; and
- non-routine, non-operational flaring that may result from activities such as planned shutdowns and ESDV testing, and unplanned shutdowns and ESDVs, production restarts, equipment outage/failures, subsea flowline depressurisation and well remediation activities.

The flaring volume is impacted by reliability of the compression system (LP compressor and HP compressor). Historically, improvements have been made on the reliability of the HP compressor, with a subsequent reduction in flaring volumes. During flaring, the burnt gas generates mainly water vapour and CO_2.

The LP compressor, which has historically been offline, and is being replaced and returned to service during the GE Project, which will improve LP flaring performance (gas recovered for reinjection). However, due to increased gas and oil production rates associated with GED, it is anticipated overall flare volumes will increase. Trips of the HP or LP compressor will result in higher volumes of flaring when compared to trips at recent production rates only associated with the Vincent reservoir. It is estimated that up to 31,000 tonnes of gas are flared per year during routine operations (Table 12-16). Overall the flare efficiency is expected to improve. The facility will continue to pursue reliability improvements for the compressors and thereby reduce flaring volumes.

Flaring volumes will vary as a result of production rates and non routine activities, outages and shutdowns. Start-up of the GE development wells will result in a temporary increase in flare emissions until steady state production is achieved. The forecast annual atmospheric emissions from flaring have been estimated using the National Pollutant Inventory (NPI) Emission Estimation Techniques (EET).

Table 12-16: Estimated Annual Atmospheric Emissions from Flaring at the NY FPSO

Component	Estimated upper flaring emissions (tonnes) [2]
Flared volume (tonnes)	31,000
CO_2	86,800
CH_4	992
N_2O	3.12
Total CO_2e	112,530
NO_X	46.5
SO_X	0
CO	269.7

** * Upper estimate 2020 flare target.*

- This assumes the greatest contribution to flaring is from the HP compression train.
- Flaring rate is calculated from the 2018 Long-term Plan (LTP) using the P50 production forecast once GED is producing. Gas profile generation is not the main purpose of the LTP and the profile is likely to change following 2019.
- This estimate is based on the year 2020 where the highest production rates are forecasted.

Non-routine venting of process hydrocarbons via Flare System

During normal operations, hydrocarbon gas is flared via the HP and LP flare systems. These systems are maintained to effectively combust hydrocarbons as a critical component for the safe operation of the NY facility. In the unlikely event that the flares are extinguished or unavailable (such as following a major shutdown prior to system ramp-up), the hydrocarbon gas discharged via the flare system may initially not be combusted during the period required to purge the flare system and re-establish flare ignition. This may result in the short term (minutes) low-rate release of hydrocarbon gas to the atmosphere.

Cargo Tank Inert Gas Venting

The inert gas system supplies inert gas to maintain a positive pressure in the vapour space of cargo tanks to prevent the ingress of air. Hydrocarbon vapour will form in the cargo tanks as volatile hydrocarbons evaporate from the stored crude oil. This vapour is displaced from the cargo tanks as they are filled and vented to the atmosphere. Maintaining inert gas in cargo tank vapour spaces is required for the safe operation of the facility.

Fugitive Emissions

Fugitive emissions can occur from pressurised equipment, and are inherent in design, required for infrequent operational activities, or can be caused by unintentional equipment leaks. Sources can include from valves, flanges, pump seals, compressor seals, relief valves, vents, sampling connections, process drains, open-ended lines, casing, tanks and other potential leakage sources from pressurised equipment.

Fugitive emissions are, by their nature, difficult to quantify. The normal approach, using the Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia National Greenhouse and Energy Reporting (Measurement) Determination 2008 guidelines, as accepted by the National Greenhouse and Energy Reporting Scheme (NGERS), is to indirectly estimate the amount of emissions based on product throughput. As much of the safe operation of the NY facility relies on the effective containment of hydrocarbons, the volumes of routine and non-routine fugitive emissions are considered small. The DoEE has released technical guidelines for estimating greenhouse gas emissions by facilities in Australia, including from fugitive emissions. Using these estimation techniques, the NY FPSO reported 1516.07 tonnes of CO_2 equivalents lost through fugitive emissions 2016–2017. As a result of the increased throughput that will occur as a result of the GE Development, fugitive emissions are expected result in a maximum of approximately 3,900 tonnes of CO_2 equivalent.

Discrete, relatively small volumes of packed gases and charged systems including refrigerant gases are used across the NY FPSO and vessels, which have potential for small volume leaks (typically less than 100 kg per isolatable inventory). Such gases are used in the HVAC and refrigerant systems onboard the NY FPSO and vessels.

Impact Assessment

Facility and vessel routine and non-routine emissions, predominantly routine fuel combustion and flaring, have the potential to result in localised, temporary reduction in air quality, generation of dark smoke, and contribution to greenhouse gas emissions. Potential impacts of emissions depend on the nature of the emissions, as well as the location and nature of the receiving environment. The incineration of wastes onboard support vessels and venting from cargo tanks are considered to result in no impact to air quality.

NY FPSO design (including the rapidly dispersive characteristics of the gas turbine exhausts, flare and other emissions), the estimated level of pollutants in the emissions, and the absence of elevated background ambient levels have been considered in estimating the potential for interaction with human and environmental sensitivities. The NY facility and Operational Area is in a remote offshore location, with no expected adverse interaction with populated areas or sensitive environmental receptors associated with air emissions.

There is a foraging BIA for the wedge-tailed shearwater overlapping the Operational Area; as such, wedge-tailed shearwaters may occur nearby to the facility airshed. The nearest potential seabird roosting habitat, Muiron Islands, lies approximately 35 km south of the Operational Area at the closest point. Given, the low numbers of individuals expected potentially within the Operational Area, combined with the highly dispersed nature of air emissions from the Petroleum Activities Program, no adverse impacts to wedge-tailed shearwaters are anticipated due to air emissions.

Potential impacts are expected to be short-term, localised air quality changes, limited to the airshed local to the NY FPSO. Air emission impacts are not expected to have direct or cumulative impacts on sensitive environmental receptors.

The flare and potential black smoke resulting from emissions may impact visual amenity. The offshore location of the NY FPSO is not directly visible from the nearest point of the mainland (North West Cape, 43 km south of the Operational Area at the closest point). Hence, no impacts to visual amenity for residential communities are expected. Visual amenity impairment to tourism activities are not expected.

Summary of Control Measures

- NY FPSO (when disconnected) and vessels operations compliant with Marine Order 97 (Marine Pollution Prevention – Air Pollution;
- NGERS and National Pollutant Inventory (NPI) reporting – estimation of greenhouse gas, energy and criteria pollutants;
- Regular monitoring, estimation and reporting of facility fuel and flare emissions (in accordance with NGERS/NPI) to inform optimisation management practices;
- Fuel gas derived from subsea wells will be used in preference to diesel for power generation;
- Maintain flare to maximise efficiency of combustion and minimise venting; and
- Reinstate LP compressor to reduce flaring.

Routine Light Emissions: Light Emissions from Platform Lighting, Vessels Operations and Operational Flaring

Impacts 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/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Light emissions from NY FPSO and vessels						X		A	F	-	-	LCS GP PJ	Broadly Acceptable
Light emissions from NY FPSO during flaring						X		A	F	-	-		

Description of Source of Impact

Lighting is used to allow safe operations and to communicate the presence of the NY FPSO and vessels to other marine users (i.e. navigation lights), and cannot reasonably be eliminated.

External lighting is located over the entire NY FPSO deck, as well as vessels, with most external lighting directed towards working areas such as the topsides of the FPSO, or the back deck of vessels. The top of the flare tower (the highest point of the facility) is approximately 90 m above the deck. External lighting on vessels is typically lower than the NY FPSO lights, with vessel lighting usually reduced to improve night vision of bridge crew.

The distance to the horizon at which components of the NY FPSO is 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 the flare tower top is visible at sea level are:

- flare tower tip: approximately 37 km from NY FPSO (based on deck height above sea level of 20 m and flare tower height of 90 m).

During IMR activities, underwater lighting is generated over short periods of time while ROVs are in use, as well as from deck lighting. Given the typical intensity of ROV lights and the attenuation of light in seawater, light from ROVs is localised to the vicinity of the ROV and vessels.

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: 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.

Potential fauna are predominantly pelagic fish and zooplankton, with a low abundance of transient species such as marine turtles, whale sharks and large whales transiting through the Operational Area. The outer portion of a critical nesting habitat for flatback turtles, as defined in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017), overlaps the Operational Area (although this habitat is not listed as a BIA). There are no other known critical habitats within the Operational Area for EPBC listed species, although there are BIAs listed that overlap the Operational Area..

Seabirds

The risk associated with collision from seabirds attracted to the light is considered to be low, given there is no critical habitat for these species within the Operational Area. There is a foraging BIA for the wedge-tailed shearwater overlapping the Operational Area; as such, wedge-tailed shearwaters may occur within the Operational Area. The nearest potential seabird roosting habitat, the Muiron Islands, lie approximately 35 km south-east of the Operational Area at the closest point. Foraging wedge-tailed shearwaters may be attracted to sources of light emission to feed upon fish drawn to the light; however, the species feeds predominantly during the day, in association with pelagic predators (Catry et al. 2009, Whittow 1997). The majority of foraging trips are short, with single day foraging trips significantly more common than any other length trip, with birds returning to nesting/roosting sites between trips (Congdon et al. 2005).

As such, the numbers of wedge-tailed shearwaters present in the Operational Area at night is expected to be low relative to daylight hours, and any potential changes to behaviour would only affect a relatively low number of birds. Given the species' global distribution and primarily diurnal foraging behaviour, impacts to wedge-tailed shearwaters from artificial lighting are considered to be highly unlikely.

In a study of offshore oil platforms in the North Sea, Poot et al. (2008) observed that migrating seabirds can be attracted to the lights and flares of offshore oil platforms, particularly on cloudy nights and in between the hours of midnight and dawn. Migratory shorebirds travelling the East Asian-Australasian Flyway may transit through the Operational Area in the vicinity of the NY FPSO and vessels en route to staging areas, before moving onto the mainland south in the spring or Indonesia in the north in the autumn. It is possible that many of the birds on migration may also take advantage of ships and offshore facilities in the area to rest. Migrating birds in the region are at, or near, the end of their migration (or staging area), and if attracted will not be facing long-distance journeys directly upon leaving the facility. Although the migratory diversion is not expected to impact negatively on the birds, if there are identified maintenance, safety and health risks associated with guano from the birds it may be necessary to deter them from resting on NY facility. No lasting effect is anticipated from seabirds attracted to the light, and hence, diverted from their migratory pathway.

Marine Turtles - Hatchlings

The nearest potential nesting site in relation to the NY FPSO is the Muiron Islands, approximately 38 km from the FPSO. Lighting and the tip of the flare tower onboard the NY FPSO will not be directly visible from this potential nesting site. Given the nature of the light emitted from the NY FPSO and vessels, and the distance to the nearest landfall (and nearest significant rookeries), the potential for hatchling turtles to become disoriented by artificial lighting is considered not credible.

Marine Turtles - Adults

Artificial lighting may affect the location where 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). The outer portion of a critical nesting habitat for flatback turtles, as defined in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017), overlaps the Operational Area (although this habitat is not listed as a BIA). Given the water depth and preferred foraging habitat, this species is expected to be present in very low numbers only. As described above, light is not predicted to be visible at the nearest potential nesting sites, so no credible impacts to nesting flatback turtles have been identified.

Fish

Lighting may result in the localised aggregation of pelagic fish below the source of light to feed on plankton aggregations. Impacts are localised and have no lasting effect on fish or plankton.

Values and Sensitives

Ningaloo World Heritage Area

Consultation with the Ningaloo Coast World Heritage Advisory Committee raised concerns of the potential for light to impact upon the outstanding values of the Ningaloo WHA. The Ningaloo WHA hosts a range of marine fauna, which are an environmental value of the WHA. Fauna in the Ningaloo WHA may be impacted by light emissions; refer to the section above for an assessment of the potential impacts of artificial light on marine fauna. Given the distance offshore

of the NY FPSO, light from the flare is unlikely to be directly visible, and hence is not considered to result in any impact to the aesthetic values of the Ningaloo WHA.
Summary of Control Measures
The potential impacts and risks from light emissions are deemed to be ALARP in its risk state. No reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice.

Unplanned Hydrocarbon or Chemical Release: Hydrocarbon Release During Bunkering/refueling and Chemical Release during Transfer, Storage and Use

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	Risk Rating	ALARP Tools	Acceptability
Accidental spill of hydrocarbons to the environment during bunkering / refueling.			X			X		A	D	2	M	LCS GP PJ	Broadly acceptable
Accidental discharge of chemicals to the marine environment from storage, use or transfer.			X			X		A	E	2	M		
Description of Source of Risk													

A range of chemicals and hydrocarbons are routinely transferred to, and stored on, the NY FPSO and support vessels.

Indicative inventories onboard the NY FPSO are provided in Section 3.8. The quantity of stored chemicals is generally limited to the volumes practically required to meet operational needs of the NY FPSO or support vessels.

Operational chemicals used during the Petroleum Activities Program are assessed and selected in accordance with the process described in Section 3.8.

Marine Diesel Bunkering/Refuelling

Marine diesel fuel is transferred to the NY FPSO by bunkering. Two key 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 500 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break and complete loss of hose volume).
- Partial or total failure of a bulk transfer hose or fittings during bunkering or refuelling, combined with a failure in procedure to shutoff fuel pumps, for a period of up to five minutes, results in approximately 13 m^3 marine diesel loss to the deck and/or into the marine environment.

Marine diesel is typically not transferred to support vessels in the Operational Area; support vessels refuel in port (i.e. beyond the scope of this EP).

Operational and Facility Maintenance Chemicals

Transfer

Operational process chemicals, non-process and facility maintenance chemicals are transferred to the NY FPSO in containers.

Spills may occur during transfer of chemicals to the NY FPSO. Given the small volumes being handled, the credible release volumes are relatively small (e.g. largest typical chemical transfer via container is approximately 3.8 m^3.

Storage and Use

Chemicals are used for a variety of purposes. Spills of chemicals (including non-process hydrocarbons such as marine diesel) can originate from hydrocarbons/chemicals or equipment on the NY FPSO, support vessel decks or subsea.

Operational process chemicals on the NY facility which are kept in larger quantities are stored in dedicated vessels which have similar controls as those related to mitigating hydrocarbon spills (e.g. dedicated tanks, permanent piping to the process, isolatable by valves, etc.). The process chemical with the largest inventory on the NY FPSO is methanol (50 m^3). Methanol is considered to be PLONOR and has an OCNS ranking of E. Operational non-process chemicals and facility maintenance chemicals on the NY facility and support vessels are typically held in low quantities (usually less than 50 L). The NY FPSO has dedicated chemical storage areas onboard, which are sufficiently bunded to retain the loss of the contents of an entire container stored within.

Chemical storage areas are typically set up in cabinets or bunded storage areas to contain any releases to deck from transportable containers (e.g. IBCs, barrels, drums, pails, etc.). Releases from equipment are predominantly from the failure of hydraulic hoses or minor leaks from process components, or spills during refuelling of equipment, which can either be located within bunded/drained areas or outside of bunded/drained areas (e.g. over grating on cranes).

Support vessels undertaking IMR activities may store quantities of chemicals for subsea use. Subsea chemical use is subject to the chemical selection process outlined in Section 3.8. Accidental releases of small quantities of subsea chemicals may occur (e.g. deck spills). Operational experience indicates potential volumes of such spills is small (<20 L). 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.

The primary diesel storage location onboard the NY FPSO and support vessels is dedicated bunker tanks within vessel hulls. Further quantities of marine diesel are stored topsides in the diesel oil settling tanks, service and storage tanks, and fuel tanks for equipment (e.g. generators). Credible spills of marine diesel during use are typically small (<50 L) compared to potential releases during bunkering. Mechanisms are available to capture diesel from process/piping associated with bunkering and fuel transfers, which can be routed to the drainage system, where the spill can be contained.

Quantitative Spill Risk Assessment

Woodside has commissioned RPS APASA to model several small marine diesel spills, including surface spill volumes of 8 m^3 in the offshore waters of northwest WA. For the purpose of this risk assessment, an 8 m^3 bunkering release is considered consistent with the 13 m^3 release scenario identified for the NY FPSO. 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. Based on this, Woodside considers there is little potential for hydrocarbon concentrations above impact thresholds resulting from a 13 m^3 release of marine diesel to extend beyond the Operational Area.

Consequence Assessment

Marine Diesel

The potential biological and ecological consequences associated with much larger diesel spills are presented in MEE-3 (topsides loss of containment) and MEE-07 (loss of marine vessel separation). Further detail on consequences specific to a spill of marine diesel from a bunkering loss are provided below.

The biological consequences of a small volume spill on identified open water sensitive receptors relate to the potential for slight consequences to megafauna, plankton and fish populations (surface and water column biota). Impacts to plankton may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities, these impacts will be short-lived (hours to days). Impacts to fish are expected to be of no lasting effect, as fish species are mobile and expected to avoid the area affected by a marine diesel spill from a bunkering incident. Impacts to larger fauna such as cetaceans and marine turtles are expected to be light fouling, potentially resulting in irritation of sensitive membranes such as the eyes, mouth and digestive system (Helm et al. 2015). Mortality of larger fauna is not expected to occur.

Given the lack of commercial fishing in the Operational Area, no impacts to commercial fishers (e.g. displacement of fishing effort, loss of catch due to taint, etc.) are expected to occur.

On the basis of the potential impacts described above, the consequence of a marine diesel spill from a bunkering incident are considered Minor and short-term.

Chemicals - Operational and Maintenance

Woodside's preference for low toxicity operational chemicals planned for discharge is integrated into Woodside's chemical selection process (Section 3.8).

The chemical stored in the largest volume on the NY FPSO is methanol, which is considered PLONOR and is OCNS rated E, and is miscible in water. TEG is miscible in water and is considered PLONOR. A maximum credible spill of methanol (or other operational chemical) is expected to mix with the offshore receiving environment, with no lasting environmental impact.

Accidental releases of chemicals will decrease the water quality in the immediate area of the release (i.e. surface waters at the release location); however, the consequence is expected to be temporary and localised due to water depths (approximately 320 to 849 m), the open ocean mixing environment, Operational Area distance from sensitive receptors and relatively low credible release volumes. Depending on the chemical released, the toxicity and/or potential to bioaccumulate may potentially result in impacts to sediment quality, pelagic fish or other marine species in the vicinity of the discharge.

As with the potential consequences of a marine diesel spill from a bunkering incident, potential impacts to plankton from an accidental chemical spill may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities and nature and scale of the credible releases, these impacts will be short-lived (hours to days). Impacts to fish are expected to be of no lasting effect, as fish species are mobile and expected to avoid the area affected by an accidental chemical spill. Impacts to air-breathing fauna such as cetaceans, birds and marine turtles, are expected to be restricted to irritation of sensitive membranes such as the eyes, mouth and digestive system.

The risk of an accidental chemical release is unlikely to result in consequences greater than a slight, short-term impact on species or minor impact to water quality.

Summary of Control Measures

- Contract vessels compliant with Marine Order 91 (Marine pollution prevention – oil) for safe vessel operations
- Chemical Selection and Assessment Environment Guideline.
  - Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required; and
  - If chemicals with a different OCNS rating, sub warning or non-OCNS rated chemicals are required chemicals will be assessed in accordance with the procedure prior to use.
- Diesel bunkering hoses to have dry break couplings and be pressure rated at purchase.
- Implementation of bunkering procedures.
- Chemicals will be stored safely to prevent the release to the marine environment.
- Incident reports are raised for unplanned releases within event reporting system.
- NY FPSO drainage system in place to contain and dispose leaks and spills of hazardous liquids.

Unplanned Discharges: Hazardous and Non-hazardous Waste Management

Risk 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	Risk Rating	ALARP Tools	Acceptability
Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.		X	X			X		A	F	2	L	LCS GP PJ	Broadly acceptable

Description of Source of Risk

Non-hazardous and Hazardous Waste

Normal operations on the NY FPSO and vessels results in a variety of hazardous and non-hazardous wastes. However, these materials could potentially impact the marine environment if incorrectly disposed or discharged in significant quantities.

Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard and scrap steel. Hazardous wastes include recovered solvents, excess or spent chemicals, oil contaminated materials (e.g. sorbents, filters and rags), batteries and used lubricating oils. Hydrocarbon production may result in naturally occurring radioactive material (NORMs) being deposited in scale within hydrocarbon-containing infrastructure (e.g. flowlines), or contained within produced sand. Monitoring to date has not indicated the presence of NORMs hydrocarbon-containing infrastructure or produced sands.

Sand and sludges may also be periodically generated during well clean-up operations, de-sanding and vessel maintenance. Waste materials generated on the NY FPSO which are not suitable for discharge to the environment, including hazardous wastes, are transported to shore for disposal or recycling by a licensed waste contractor

Consequence Assessment

Non-hazardous and Hazardous Waste

The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the environment, potentially resulting in decreased water or sediment quality. Secondary impacts due to potential contact with individual marine fauna includes entanglement or ingestion, which may lead to injury and/or death.

The temporary or permanent loss of hazardous or non-hazardous waste materials into the marine environment is not likely to have a significant environmental impact, based on the location of the Operational Area, the types, size and frequency of wastes generated, and the species present.

Summary of Control Measures

- Contract vessels compliant with Marine Orders for safe vessel operations:
  - Marine Order 94 (Marine pollution prevention – packaged harmful substances) 2014; and
  - Marine Order 95 (Pollution prevention – Garbage).
- Management of NORMs in accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) guidelines.
- Implementation of Waste Management Plan for Offshore Facilities.
- If safe and practicable to do so; vessel ROV or crane used to attempt recovery of material[5] environmentally hazardous or non-hazardous solid object/waste container lost overboard. Incident reports are raised for unplanned releases within event reporting system.
- Incident reports are raised for unplanned releases within event reporting system

[5] *For the purposes of this control/performance standard "material" is defined as unplanned releases of environmentally hazardous or non-hazardous solid object/waste events with an environmental consequence of >F.*

Physical Presence: Vessel Collision with Marine Fauna

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	Risk Rating	ALARP Tools	Acceptability
Physical presence of vessels resulting in collision with marine fauna.						X		A	E	1	L	LCS GP PJ	Broadly Acceptable

Description of Source of Risk
The vessels operating in and around the Operational Area may present a potential hazard to cetaceans 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 frequency and severity of impacts due to collisions vary due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth), and the type of marine fauna potentially present and their behaviours.
Consequence Assessment

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, List et al. 2001). Vanderlande 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. According to the data of Vanderlin 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, there 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 among whales (Jensen and Silber 2004).

Vessels undertaking the Petroleum Activities Program within the Operational Area are likely to be travelling less than 8 knots; much of the time vessels are holding station. Therefore, the risk of a vessel collision with protected species resulting in death is inherently low. No known key areas (resting, breeding or feeding) are located within or immediately adjacent to the Operational Area.

The Operational Area overlaps the outer portion of the humpback whale migration BIA (Section 4.3.4); humpback whales are seasonally abundant within this corridor during their annual migrations. Aerial surveys undertaken by Woodside indicate that the majority of humpback whales migrating in the region typically occur east of the Operational Area; the majority of the whales occurred in depths less than 500 m, with the greatest density of whales concentrated in water depths of 200 to 300 m (RPS Environment and Planning 2010a). Humpback whales have also been observed in the Operational Area during their seasonal migration by personnel onboard the NY FPSO. As such, humpback whales occur in the Operational Area during their seasonal migration period. However, harmful interactions between vessels and humpback whales in the Operational Area are considered highly unlikely due to the slow speed of vessels in the Operational Area.

A pygmy blue whale migration BIA also overlaps the Operational Area. Analysis of underwater noise logger data indicated pygmy blue whales are present in waters off North West Cape between October to December (northbound migration) and April to August (southbound migration) (McCauley and Jenner 2010). Satellite tagging studies have shown pygmy blue whales migrating along the Western Australian coast near the Operational Area in water depths between 200 m and 1000 m, which includes the depth range of the Operational Area (approximately 340 to 849 m). Pygmy blue whales were not recorded in a series of whale monitoring flights between July and September (RPS Environment and Planning 2010a), although these flights were intended to record humpback whales and did not extensively sample deeper waters preferred by pygmy blue whales. Observations of whales by personnel onboard the NY FPSO have not confirmed the presence of pygmy blue whales in the Operational Area.

Given the seasonality of humpback whales in the Operational Area, and seasonality and low density of pygmy blue whales recorded in the Operational Area, harmful interactions between vessels and whales during the Petroleum Activities Program are considered unlikely. Given the typical speeds of vessels within the Operational Area, any collision between vessels and whales is not expected to result in mortality.

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 waters, including the Operational Area, during their migrations to and from Ningaloo Reef, and a BIA for foraging whale sharks lies approximately 6 km from the Operational Area. However, it is not expected whale sharks would occur in large numbers within the Operational Area, given there is no main aggregation area within the vicinity of the Operational Area, and their presence would be transitory and of a short duration. There are no constraints preventing whale sharks from moving away from vessels (e.g. shallow water or shorelines).

With consideration of the absence of potential nesting or foraging habitat for turtles (i.e. no emergent islands, reef habitat or shallow shoals) and the water depth, it is considered that the Operational Area is unlikely to represent important habitat for marine turtles. No marine turtle BIAs overlap the Operational Area. The outer portion of a critical nesting habitat for flatback turtles identified in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017) overlaps the Operational Area; however, marine turtles (including flatback turtles) are considered unlikely to be present due to the distance from shore and water depth (approximately 340 to 849 m). Individual turtles have been infrequently observed by personnel onboard the NY FPSO, but turtles are not regularly seen. Individual turtles may infrequently transit the area. It is acknowledged that there are significant nesting sites along the mainland coast and islands of the region.

The typical response from turtles on the surface to the presence of vessels is to dive (a potential "startle" response), which decreases the risk of collisions (Hazel et al. 2007). As with cetaceans, the risk of collisions between turtles and vessels increases with vessel speed (Hazel et al. 2007). Given the low speeds of vessels undertaking the Petroleum Activities Program, along with the expected low numbers of turtles within the Operational Area, interactions between vessels and turtles are considered highly unlikely.

It is unlikely that vessel movement associated with the Petroleum Activities Program will have a significant impact on marine fauna populations given:

- the low presence of transiting individuals;
- avoidance behaviour commonly displayed by whales, whale sharks and turtles; and
- low operating speed of the activity support vessels (generally less than 8 knots or stationary, unless operating in an emergency).

Activities are considered unlikely to result in a consequence greater than minor short-term disruption to individuals or

a small proportion of the population, and no impact on critical habitat or fauna activity.
Summary of Control Measures
• EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans.

Physical Presence: Introduction of Invasive Marine Species

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	Risk Rating	ALARP Tools	Acceptability
Invasive species in vessel ballast tanks or on vessels / submersible equipment.					X	X	X	A	E	1	L	LCS GP PJ	Broadly Acceptable

Description of Source of Risk

The NY facility relies on vessels to service routine needs, offtake cargo, and, less frequently, to provide specialist services (subsea IMR activities, etc.). Vessels are potential vectors for the introduction of invasive marine species (IMS) to the Operational Area during the Petroleum Activities Program, and include:

- facility support vessels: typically sourced from Australian waters and generally considered to be low risk, these vessels are the most commonly used vessels in the Operational Area;
- offtake tankers: typically from international waters and generally considered to be low risk, these tankers may visit the Operational Area every eight days following start-up of the GE tieback, with offtake frequency declining as production rates decline; offtake operations may take up to 30 hrs to complete; and
- subsea support vessels – may be sourced from Australia or overseas, depending on requirements and vessel availability.

The NY FPSO may leave the Operational Area to avoid dangerous weather and undergo modifications and repairs. This may include spending short periods of time in areas that are considered high risk for the presence of potential IMS, such as ports beyond Australian waters.

IMS may be introduced to the Operational Area through:

- the discharge of ballast water; and
- release of IMS propagules/fragments from biofouling.

Potential IMS can be drawn into ballast tanks during on-boarding of ballast water as cargo is unloaded or to balance vessels under load. Offtake tankers use ballast water to maintain vessel stability. This ballast is discharged when loading crude oil from the NY FPSO during offtake operations.

The NY FPSO may require ballast water to operate safely when detached from the STP mooring. Ballast water taken on within the Operational Area (i.e. prior to detachment) is considered unlikely to host IMS due to the offshore location and deep water (approximately 340 to 849 m water depth). When returning from beyond Australian waters, the NY FPSO routinely undertakes ballast water exchanges to achieve low risk ballast water.

Ballast water exchanges are not typically required by facility support or subsea vessels. All support and subsea vessels are required to have low risk ballast water on-board prior to being contracted to Woodside.

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 surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Biofouling organisms can become established in an area through the release of propagules (e.g. eggs or larvae), or by attaching to substrate after becoming detached from the host vessel.

Consequence Assessment

Non-indigenous Marine Species (NIMS) have been introduced into a region beyond their natural biogeographic range and can survive, reproduce and establish founder populations. Not all NIMS introduced into an area will thrive or cause demonstrable impacts. Indeed, the majority of NIMS around the world are relatively benign; few have spread widely beyond sheltered ports and harbours. Only a subset of NIMS that become abundant and impact social/cultural, human health, economic and/or environmental values can be considered IMS.

IMS have historically been introduced and translocated around Australia by a variety of human means, including biofouling and ballast water. Species of concern are those that are:

- not native to the region;
- likely to survive and establish in the region; and
- able to spread by human mediated or natural means.

Species of concern vary from one region to another depending on various environmental factors such as water temperature, depth, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities. IMS are typically species that occur in shallow water, and hence are unlikely to survive in much of the Operational Area; the NY FPSO hull, the STP mooring and sections of risers near the sea surface are the only substrates considered suitable for establishment of potential IMS.

Introducing IMS into the local marine environment may alter the ecosystem, as IMS have characteristics that make them superior (in a survival and/or reproductive sense) to indigenous species. They may prey upon 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.

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 captured 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.

Despite the potential high consequence of the establishment of a marine pest within a high value environment as a result of introduction, unlike coastal or sheltered nearshore waters, the deep offshore open waters of the Operational Area are not conducive to the settlement and establishment of IMS. The Petroleum Activities Program is undertaken in an open ocean, offshore location away from shorelines and/or critical habitat, more than 12 nm from a shore and in waters approximately 340 to 849 m deep. The impacts of introducing a marine pest in this offshore location would have a lower consequence than introduction within a nearshore location, as the introduction of IMS and associated establishment is considered highly unlikely.

When examining the potential impacts from translocation of marine pests to the NY facility itself, interactions with the facility and any support vessels (most likely Australian sourced) and tankers are limited, with time within the 500 m Petroleum Safety Zone around the facility limited to support vessel transfers/bunkering. However, the risk of this occurring is considered manageable, given the ballast water and biofouling controls which are implemented for the Petroleum Activities Program.

Summary of Potential Impacts to environment value (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 marine pest translocation associated with the activity. 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 E (Environment) and likelihood as Highly Unlikely (1), resulting in an overall Low risk following the implementation of identified controls.

IMS Introduction Aspect	Credibility of Introduction	Consequence of Introduction	Likelihood
Transfer of IMS from infected vessel to operational area and establishment on the seafloor or subsea infrastructure.	**Not Credible** The deep offshore open waters of the Operational Area, away from shorelines and/or critical habitat, more than 12 nm from a shore and in waters 320 – 849 m deep are not conducive to the settlement and establishment of IMS.		
Transfer of IMS from infected vessel to and subsequent establishment on the NY FPSO..	**Credible** There is potential for the transfer of marine pests to occur.	Slight (E) – Environment Minor (D) – Reputation and Brand If IMS were to establish, this would potentially result in fouling of intakes (depending on the pest introduced), and	Highly Unlikely (1) Interactions between the NY FPSO and support vessels will be limited during the petroleum activity program, with a 500m safety exclusion zones being

		likely result in the quarantine of the NY FPSO until eradication could occur (through cleaning and treatment of infected areas). This would be costly to undertake. Such introduction would be expected to have Minor (D) impact to Woodside's reputation and brand, and close scrutiny of asset level operations or future proposals. Environmental consequence of introduction of IMS to the NY FPSO is considered Slight (E), localised, and would relate to habitat directly on the NY FPSO.	adhered too. Offtake tankers are considered to present a low IMS risk do not directly contact the NY FPSO and are within the Operational Area for short periods of time (typically <36 hrs). Spread of marine pests via ballast water or spawning in these open ocean environments is considered Highly Unlikely (1).
Transfer of IMS when NY FPSO is disconnected returns to Operational Area from Shipyard.	**Credible** There is potential for the transfer of marine pests to occur.	Slight (E) – Environment Minor (D) – Reputation and Brand If IMS were to return on the FPSO and establish, this would potentially result in fouling of intakes (depending on the pest introduced), and likely result in the quarantine of the NY FPSO until eradication could occur (through cleaning and treatment of infected areas). This would be costly to undertake. Such introduction would be expected to have Minor (D) impact to Woodside's reputation and brand, and close scrutiny of asset level operations or future proposals. Environmental consequence of introduction of IMS to the NY FPSO is considered Slight (E), localised, and would relate to habitat directly on the NY FPSO	Highly Unlikely (1) Interactions between the NY FPSO and support vessels will be limited during the Petroleum Activities Program, with a 500 m Petroleum Safety Zone being adhered to. In addition controls will be implemented (refer to ALARP discussion below) on return of NY from Singapore to limit likelihood of IMS translocation. Spread of marine pests via ballast water or spawning in these open ocean environments is considered Highly Unlikely (1).
Transfer of IMS from infected vessel to a subsequent establishment on NY FPSO, then transfer of IMS to a secondary vessel from the NY FPSO.	**Not Credible** Risk is considered so remote that it is not credible for the purposes of the Petroleum Activities Program. The transfer of a marine pest from an infected activity vessel to the NY FPSO was already considered highly unlikely, given the offshore open ocean environment. For a marine pest to then establish into a mature spawning population on the NY FPSO and then transfer to another support vessel is not considered credible (i.e. beyond the Woodside risk matrix). The NY FPSO is in an offshore, open ocean, deep environment.		

	Support vessels only spend short periods of time alongside the NY FPSO (i.e. during backloading or bunkering activities). There is also no direct contact (i.e. they are not tied up alongside) during these activities. It's also noted that Woodside has been conducting marine vessel movements between the NY FPSO and WA ports (such as Dampier) for a long period of time, and no IMS has been detected in these ports (DoF 2017).		

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 will be applied to vessels undertaking the Petroleum Activities Program.
    - 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.
- Inspection of NY FPSO by IMS Inspector prior to return from international sailaway

Unplanned Hydrocarbon Release: Loss of Well Containment (MEE-01)

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	Risk Rating	ALARP Tools	Acceptability
Release of hydrocarbons resulting from loss of subsea well containment..		X	X	X	X	X	X	B	A	1	H	LCS GP PJ RBA CV SV	Acceptable if ALARP

Description of Source of Risk

Background

A loss of well containment can lead to an uncontrolled release of reservoir hydrocarbons or other well fluids to the environment. Woodside has identified a well blowout as the scenario with the worst case credible environmental outcome as a result of this event. The causes of a loss of well containment are:

- internal corrosion;
- external corrosion;
- erosion;
- overpressure of the annuli;
- fatigue; and
- loss of control of suspended load from vessel (operating near subsea wells).

A number of common failure causes due to human error and Safety Critical Equipment (SCE) failures are presented in the generic Human Error and SCE failure section below.

Loss of Well Containment – Credible Scenarios

The Petroleum Activities Program includes production from a series of platform and subsea wells, including the GE wells. Two credible worst-case loss of well containment scenarios were identified for the Petroleum Activities Program:

- Scenario 1 - Well blow-out at surface – platform wellhead release; and
- Scenario 2 - Well blow-out at seabed – highest flow rate subsea well.

Properties of the CIM and NOL reservoir fluids are sufficiently different to result in variation in the predicted potential impacts of a subsea well blowout from the largest producing well in each field. As such, a subsea well blowout from both the Cimatti and Norton-over-Laverda reservoirs is presented here. Blowouts from wells in the other reservoirs produced by the NY FPSO (Laverda and Vincent) are not considered worst case, due to their lower flow rates and similar reservoir fluid properties.

Each loss of well containment scenario was assumed to have a duration of 77 days. This duration is based on the estimated time required to successfully drill an intervention well (refer to Appendix D for additional discussion of relief well timing). The characteristics of each of these release scenarios are summarised in Table 5 22. The characteristics of Cimatti and Norton-1 crude were used as the basis for modelling the loss of well containment scenarios.

Table 12-17: Summary of worst-case loss of well containment hydrocarbon release scenarios

Scenario	Hydrocarbon	Rate (m^3/day)	Duration (days)	Depth (m)	Latitude (D°M'S'' S)	Longitude (D°M'S'' E)	Total Condensate Release Volume (m^3)
Well blowout – Cimatti	Cimatti crude	3640	77	531	21° 26' 44" S	113° 58' 15" E	280,300

Well blowout – Norton-over-Laverda	Norton-1 crude	2973	77	825	21° 31' 0.803" S	113° 51' 13.243" E	228,900

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in well design, construction and operation. 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. The NY facility has never experienced a worst-case loss of well containment in its operational history.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons as a result of well loss of containment is considered an MEE (MEE-01). The hazard associated with this MEE is hydrocarbons in subsea wells tied-back to the NY FPSO..

Quantitative Spill Risk Assessment

Stochastic spill modelling of each of the worst case credible loss of well containment spill scenarios was undertaken by RPS APASA, on behalf of Woodside, to determine the fate of hydrocarbons released in each scenario based on the assumptions in Section 5.4. Stochastic modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volumes for all loss of well containment scenarios

Hydrocarbon Characteristics

Cimatti Crude

Cimatti crude contains a relatively high proportion (~28% by mass) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment. The unweathered mixture has a dynamic viscosity of 8.8 cP. The pour point of the whole oil (<-36°C) ensures fresh Cimatti crude will remain in a liquid state over the annual temperature range at the release location.

Cimatti crude is composed of hydrocarbons that have a wide range of boiling points and volatilities at atmospheric temperatures, which begin to evaporate at different rates on exposure to the atmosphere (Figure 12-2). Evaporation rates will increase with temperature, but in general, about 11.6% of the oil mass should evaporate within the first 12 hours (BP <180°C); a further 18.5% should evaporate within the first 24 hours (180°C < BP <265°C); and a further 41.8% should evaporate over several days (265°C < BP <380°C).

Selective evaporation of the lower boiling-point components will lead to a shift in the physical properties of the remaining mixture, including an increase in the viscosity and pour point. This may result in solidification and/or sinking of the weathered hydrocarbon over time.

The whole oil has low asphaltene content (<0.5%), indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle.

Soluble aromatic hydrocarbons contribute approximately 16.1% by mass of the whole oil, with a large proportion (10.5%) in the C16–C20 range of hydrocarbons. These compounds will evaporate slowly, leaving the potential for dissolution of a proportion of them into the water.

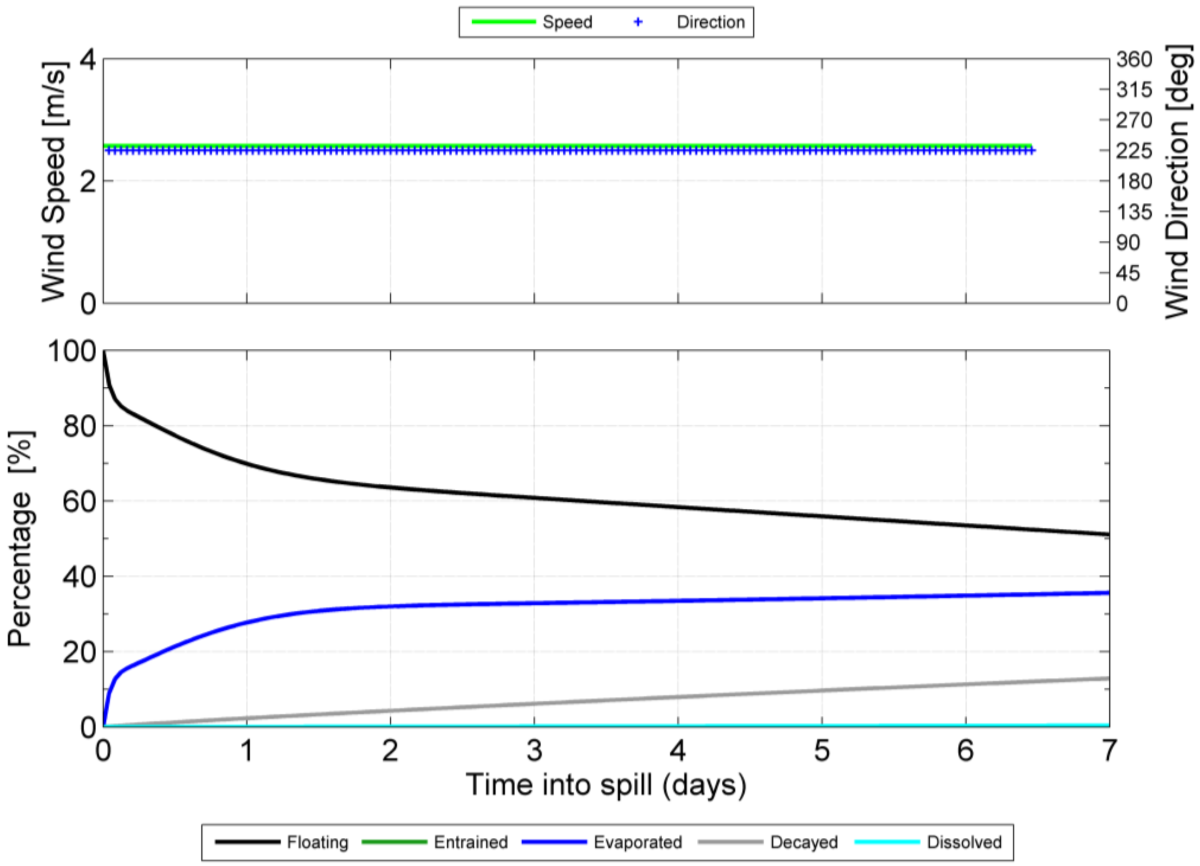

Figure 12-2: Proportional mass balance plot representing the weathering of Cimatti crude spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to constant 5 kn (2.6 m/s) wind at 27°C water temperature

Norton-1 Crude

Norton-1 crude contains a high proportion (~48% by mass, compared to Cimatti crude with ~28% by mass) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment. The unweathered mixture has a high dynamic viscosity (157.5 cP). The pour point of the whole oil (<-24°C) ensures that fresh Norton-1 crude will remain in a liquid state over the annual temperature range observed at the release location.

The mixture is composed of hydrocarbons that have a wide range of boiling points and volatilities at atmospheric temperatures, and which begin to evaporate at different rates on exposure to the atmosphere (**Figure 12-3**). Evaporation rates will increase with temperature, but in general about 1% of the oil mass should evaporate within the first 12 hours (BP <180°C). A further 14% should evaporate within the first 24 hours (180°C < BP <265°C), and a further 37% should evaporate over several days (265°C < BP <380°C).

Selective evaporation of the lower boiling-point components will lead to a shift in the physical properties of the remaining mixture, including an increase in the viscosity and pour point. This may result in solidification and/or sinking of the weathered hydrocarbon over time.

The whole oil has low asphaltene content (<0.02%), indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle.

Soluble aromatic hydrocarbons contribute approximately 11.7% by mass of the whole oil, compared to 16.1% of Cimatti crude, mostly in the C16-C20 range of hydrocarbons. These compounds will evaporate slowly, leaving the potential for dissolution of a proportion of them into the water.

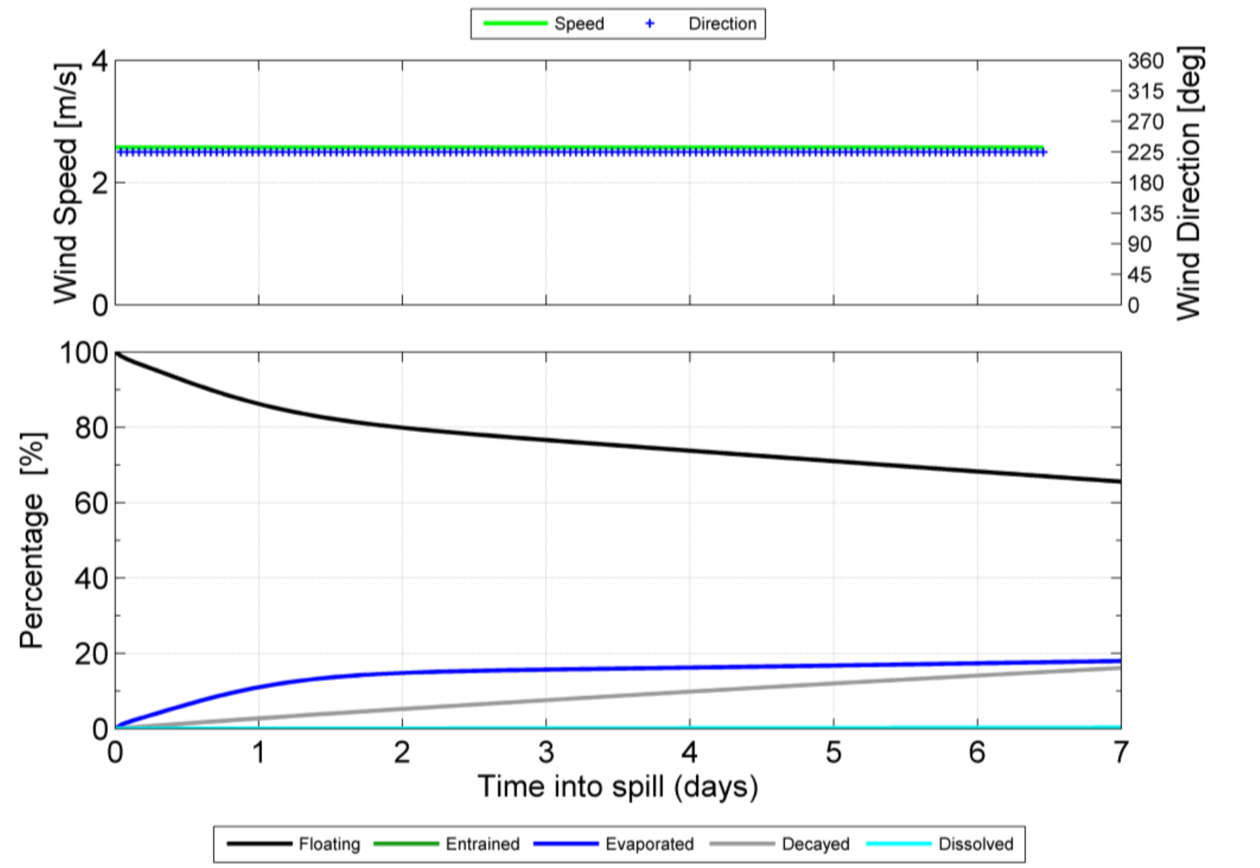

Figure 12-3: Proportional mass balance plot representing the weathering of Norton-1 crude spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to constant 5 kn (2.6 m/s) wind at 27°C water temperature

Subsea Plume Dynamics

Both loss of well containment scenarios will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model.

Likelihood

In accordance with the Woodside Risk Matrix, a worst-case loss of well containment has been defined as a 'highly unlikely' event as it 'has occurred once or twice in the industry' (experience based likelihood) and aligns with a frequency of a '1 in 10,000 to 1 in 100,000 year' event. Information to support this likelihood determination is outlined below. This assessment considers the likelihood of either worst case credible scenario occurring.

A review of industry statistics indicates that the probability of a loss of well containment for production wells is low (10.6% of 292 recorded blowouts), relative to other activities in other hydrocarbon provinces (Gulf of Mexico and the North Sea), such as exploration drilling (31.5% of blowouts), development drilling (23.6% of blowouts) and well workovers (20.5% of blowouts) (SINTEF 2017).

Separate analysis of blowout data collected between 1991 and 2010 in the North Sea and the US Gulf of Mexico shows that only ten blowouts occurred during the production phase at a frequency of 1.36 x 10–5 blowouts per well year, with all of these events occurring in the US Gulf of Mexico and none occurring in the North Sea (Scandpower 2013). North Sea standards of well design and operation are considered to be aligned with those applied by Woodside, as outlined in the NY Well Operations Management Plan (WOMP) (Woodside Doc No. VA9900AD1400199289). This data quantitatively supports the likelihood ranking as described above.

When considering likelihood from an 'Experience' perspective, and considering the likelihood of the environmental consequence of the blowout event, historic blowouts that have had catastrophic impact to the environment ('A' consequence rating) are infrequent in the industry, which further supports the likelihood ranking of 'Highly Unlikely'.

Consequence

The spatial extent and fate (including weathering) of the spilled hydrocarbons were considered during the impact assessment for both identified worst-case loss of well containment scenarios (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of either worst case spill event, and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Zone of Consequence

Surface Hydrocarbons

As described in Section 5.4, the ZoC depicted in these figures are a summary of all the locations where environmental thresholds could be exceeded for modelled scenarios.

The stochastic modelled floating hydrocarbon ZoC from both loss of well containment is forecast to drift in all directions, reflecting the competing influence of both surface currents and winds across the wide area in which a large and persistent slick could travel over the long duration of the release. At the surface threshold of 10 g/m^2, floating oil is forecast to potentially occur up to approximately 2000 km from the release site for both scenarios. The floating hydrocarbon ZoC for Norton-1 crude was predicted to travel further south than Cimatti, as it is more persistent. Due to the relatively persistent nature of the Cimatti crude, modelling indicated potential contact above impact thresholds at a number of receptors (**Table 12-18**).

Entrained Hydrocarbons

Stochastic modelling indicated entrained hydrocarbons are forecast to potentially drift in all directions, with the most likely directions of travel being to the south west of the release site, due to the influence of the NWMR seasonal currents. The modelling indicated that the entrained hydrocarbon ZoC above the 500 ppb threshold concentrations could potentially occur up to 1700 km and 1500 km for Cimatti and Norton-1 loss of well containment scenarios respectively; contact above impact thresholds was forecast at a range of receptors (**Table 12-18**). The entrained ZoC from a subsea release of Cimatti crude was predicted to extend further than Norton-1, potentially due to the higher flow rate and lower viscosity increasing the potential for entrainment.

Dissolved Hydrocarbons

In the event of a loss of well containment scenario, a plume of dissolved hydrocarbons would potentially drift in all directions, with the most likely directions of travel being to the south-west of the release site, due to the influence of the NWS seasonal currents. Stochastic modelling results indicated contact above impact thresholds may occur at a range of receptors (**Table 12-18**). The dissolved plume from the Cimatti loss of well containment was forecast to potentially extend considerably further (approximately 1500 km) than the dissolved plume from the Norton-1 loss of well containment, due to the greater soluble hydrocarbon component and larger release volume.

Accumulated Hydrocarbons

The persistent components of the hydrocarbons from the Cimatti and Norton-1 loss of well containment scenarios, in conjunction with the large surface and entrained ZoC, indicate there is considerable potential for shoreline accumulation above impact thresholds at a number of receptors (**Table 12-18**). Modelling indicated potentially large volumes of hydrocarbons may be stranded on shorelines as far as the Indonesian coastline and the Abrolhos Islands.

Table 12-18: Zone of Consequence (ZoC) – key receptor locations and sensitivities with the summary hydrocarbon spill contact for a loss of well containment (table cell values correspond to scenario numbers)

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		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 deep water 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 and 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 waters	C	C					C		C					C	C				C	C	C	C	C		C		C		C	C	C	C	
	Kimberley CMP	C	C	C	C		C	C		C					C	C	C		C	C		C	C	C	C			C	C		C			
	Argo-Rowley Terrace CMP	C, N						C, N							C, N	C, N			C, N			C, N	C, N	C, N		C, N			C, N		C, N	C, N		
	Shark Bay Open Ocean (including CMP)	C, N	C, N					C, N							C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C
	Abrolhos CMP	C, N	C, N					C, N							C, N	C, N		C, N		C, N		C, N	C, N	C, N	C, N	C, N			C, N		C, N	C, N	N	
	Carnarvon Canyon CMP	C, N	C, N					C, N		C, N														C, N	C, N	C, N			C, N		C, N	C, N	C	
	Gascoyne CMP	C, N	C, N												C, N	C, N			C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	
	Geographe CMP	C, N						C, N		C, N					C, N	C, N						C, N	C, N	C, N	C, N			C, N	C, N			C, N		
	Jurien CMP	C, N	C, N		C, N		C, N				C, N				C, N			C, N				C, N	C, N	C, N	C, N	C, N		C, N	C, N			C, N	C	
	Montebello CMP	C, N	C, N	C, N			C, N	C, N							C, N	C, N			C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C	
	Perth Canyon CMP	C, N						C, N							C, N	C, N							C, N	C, N	C, N				C, N		N	C, N		
	South-west	C,						C,		C,					C,	C,		C,				C,	C,	C,	C,			C, N	C, N		N	C, N		

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

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		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 deep water 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 and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
	Corner CMP	N						N		N					N	N		N				N	N	N	N									
	Two Rocks CMP	C, N	C, N					C, N					C, N		C, N			C, N					C, N	C, N	C, N	C, N			C, N			C, N	C	
Oceanic Reefs and Offshore Islands	Ashmore Reef and CMP	C, N	C, N	C, N	C, N		C, N	C, N				C, N				C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N		C, N	C, N	C, N					C, N
	Browse Island	C	C	C	C		C	C		C		C							C	C		C	C	C	C									C
	Cartier Island and CMP	C, N	C, N	C, N	C, N		C, N	C, N				C, N				C, N			C, N	C, N		C, N	C, N	C, N	C, N		C, N		C, N					C, N
	Seringapatam Reef	C	C	C	C		C	C		C		C				C			C	C		C	C	C	C		C	C	C		C			
	Scott Reef (North, Central and South)	C, N	C, N	C, N	C, N		C, N	C, N		C, N		C, N			C, N	C, N			C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N		C			C, N
	Mermaid Reef CMP	C, N	C, N	C, N			C, N	C, N		C, N						C, N			C, N	C, N		C, N	C, N	C, N	C, N			C, N	C, N		C, N			
	Clerke Reef and State Marine Park	C, N	C, N	C, N			C, N	C, N		C, N						C, N			C, N	C, N		C, N	C, N	C, N	C, N			C, N	C, N		C, N			C, N
	Imperieuse Reef and State Marine Park	C, N	C, N	C, N			C, N	C, N		C, N						C, N			C, N	C, N		C, N	C, N	C, N	C, N			C, N	C, N		C, N			C, N
Submerged Shoals and banks	Rankin Bank	C, N	C, N	C, N			C, N	C, N		C, N						C, N				C, N		C, N		C, N	C, N	C, N		C, N			C, N	C		
	Glomar Shoals	C	C	C			C	C		C						C				C		C		C	C	C		C			C			
	Rowley Shoals (including State Marine Park)	C	C	C			C	C		C						C				C		C		C	C	C		C			C			C

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		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 deep water 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 and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
Islands	Montebello Islands (including State Marine Park)	C, N	C, N	C, N	C, N	C, N	C, N	C, N				C, N		C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	N	C
	Lowendal Islands (including State Nature Reserve)	C, N	C, N	C, N	C, N		C, N	C, N				C, N		C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C		C, N
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	C, N	C, N	C, N	C, N		C, N	C, N				C, N		C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C	C, N
	Muiron Islands (WHA, State Marine Park)	C, N	C, N	C, N	C, N		C, N	C, N		C, N		C, N		C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N			C, N	C, N		C, N	C, N	C, N	C, N
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	C, N	C, N		C, N		C, N		C, N			C, N		C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N
	Pilbara Islands – Middle Island Group	C, N	C, N		C, N		C, N		C, N			C, N		C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		N			C, C

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		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 deep water 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 and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
	Pilbara Islands – Northern Island Group (Sandy Island Passage Islands – State Nature Reserves)	C, N	C, N		C, N		C, N		C, N			C, N		C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		N			C, N
	Bernier and Dorre Islands	C, N	C, N	C, N	C, N		C, N	C, N			C, N	C, N		C, N		C, N			C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		C	C	C	C
	Abrolhos Islands	C, N	C, N	C, N	C, N	C, N	C, N	C, N				C, N		C, N	C, N	C, N		C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		C	C, N	C	C. N
Mainland (nearshore waters)	Southern Pilbara Shoreline	C, N	C, N	C, N	C, N	C, N	C, N				C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N			N			C, N
	Middle Pilbara Shoreline	C, N	C, N	C, N	C, N	C, N	C, N				C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N			N			C, N
	Northern Pilbara Shoreline	C, N	C, N	C, N	C, N	C, N	C, N				C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N			N			C
	Ningaloo Coast (North, Middle and South WHA)	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N		C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N
	Dampier Archipelago	N	N	N	N	N	N				N	N		N		N	N		N	N		N	N	N	N	N		N	N					N
	Exmouth Gulf	C	C		C	C	C	C				C	C		C	C	C		C	C		C	C	C	C	C		C				C		C
	Shark Bay – Open Ocean Coast	C, N	C, N	C, N	C, N		C, N	C, N			C, N	C, N		C, N		C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		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 deep water 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 and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
	Shark Bay – WHA and Marine Park	C, N	C, N	C, N	C, N	C, N	C, N					C, N		C, N	C, N	C, N	C, N		C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N
Indonesia	Sumba, Pulau Roti, Savu, Timor West	C, N	C, N	C, N	C, N	C, N	C, N				C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N	C, N	C, N	C, N	C, N		C, N	C, N	C, N		C, N			C, N
East Timor	East Timor	N	N	N	N	N	N				N	N	N	N	N	N	N		N	N	N	N	N	N	N		N	N	N					N

Summary of Potential Impacts to environmental values(s)	
Summary of Potential Impacts to protected species	
Setting	**Receptor Group**
Offshore, Oceanic Reefs and Islands	**Cetaceans** A range of cetaceans were identified as potentially occurring with the Operational Area 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). Given the relatively low volatile fractions of the hydrocarbons, the area where potential impacts from inhalation may occur is expected to be localised around the release location. 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). 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 travelling 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 in Section 4.3.4 may also have possible transient interactions with the ZoC (refer to **Table 12-18** for the list of receptor locations for cetaceans). Pygmy blue whales and humpback whales are known to migrate seasonally through the wider ZoC, and the migration BIAs in the region for both species overlap the Operational Area. A major spill in May to November would coincide with humpback whale migration through the waters off the Pilbara, North West Cape and Shark Bay. A major spill in April–August or October–January would coincide with pygmy blue whale migration. Both pygmy blue and humpback whales are baleen whales, so 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. The entrained hydrocarbon ZoC includes pygmy blue whale foraging BIAs off the Ningaloo Coast (approximately 17 km from Operational Area) and the Rottnest Canyon (approximately 1143 km from the Operational Area). 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. 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 integrity 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 disrupt a significant portion of the humpback or pygmy blue whale populations. 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 the overall population viability of cetaceans, given the global distribution of these species.

	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 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.
	Pinnipeds Australian sea lions are found on and around the Abrolhos Islands, distant from the Operational Area, but within the wider ZoC. Given the considerable distance from the Operational Area to these receptors, and the time for floating and entrained hydrocarbons to contact (minimum 32 days for the Abrolhos Islands), entrained hydrocarbons that do reach this area are likely to be weathered. There is the potential for sea lions to interact with floating and stranded hydrocarbons. This may result in diminished ability to thermoregulate due to the loss of insulation, potentially resulting in mortality. Potential impacts are expected to be minor and temporary at a population scale.

	Marine Turtles Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon spills (National Oceanic and Atmospheric Administration 2010). Contact with surface slicks, or entrained hydrocarbon, can therefore 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). 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, causing irritation of mucous membranes in the nose, throat and eyes and leading to inflammation and infection (Gagnon and Rawson 2010). Due to the absence of potential nesting habitat and location offshore, the Operational Area is unlikely to represent important habitat for marine turtles. It is acknowledged that foraging marine turtles may be present foraging within the ZoC, and the ZoC would overlap with the BIAs identified in Section 4.3.4, in particular the inter nesting BIAs and critical habitats for flatback turtles which extend for ~80 km from known nesting locations. It is noted by Woodside that the Petroleum Activities Program will overlap nesting seasons for marine turtles in the region. In the event of a well blowout, there is potential that surface, entrained and dissolved hydrocarbons exceeding threshold concentrations will be present in offshore waters extending up to 2000 km, 1700 km and 1500 km, respectively, from the release site. Therefore, a hydrocarbon spill may disrupt a portion of the population; however, there is no threat to overall population viability. Potential impacts to nesting and inter-nesting 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. They 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. 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 may be present in the Operational Area and are present in the wider ZoC (refer to **Table 12-18**); however, their abundance is not expected to be high in the deep water and offshore environment. Therefore, a hydrocarbon spill may disrupt a portion of seasnake populations, but there is no threat to overall population viability given their widespread distribution in tropical waters.
	Sharks (including whale 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 (see Mainland and Islands (nearshore waters) below). Whale sharks may also carry out opportunistic feeding in offshore waters and the Operational Area. The ZoC overlaps the whale shark migration and foraging BIA identified in Section 4.3.4, within which whale sharks are seasonally present between April and October. Therefore, individual whale sharks that have direct contact with hydrocarbons within the spill affected area may be impacted, but the consequences to migratory whale shark populations are likely to be minor. 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 only a temporary disruption.
	Seabirds and Migratory Shorebirds Offshore waters are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat (e.g. Ningaloo, Muiron Islands and the Barrow/Montebello/Lowendal Island Group). There are confirmed foraging grounds off Ningaloo and the Barrow/Montebello/Lowendal Island Group. A BIA for the wedge-tailed shearwater (peak use August–April) overlaps with the Operational Area. There are also a number of BIAs for seabirds and migratory shorebirds that overlap with the wider ZoC, as provided in Section 4.3.4. 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). Seabirds generally do not exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by several exposure pathways, primarily immersion, ingestion and inhalation. Such contact with hydrocarbons may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (Australian Maritime Safety Authority 2013, International Petroleum Industry Environmental Conservation Association 2004), and result in mortality due to oiling of feathers or the ingestion of hydrocarbons. Longer term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chicks (Australian Maritime Safety Authority 2013). A hydrocarbon spill may result in surface slicks disrupting a significant portion of the foraging habitat for seabirds, including BIAs identified for foraging birds which are generally associated with breeding habitat, and seabirds foraging in waters in proximity to these sites. Seabird distributions are typically concentrated around islands, so hydrocarbons in proximity to nesting/roosting areas may result in increased numbers of seabirds being impacted, with many species of seabirds, such as the wedge tailed shearwater and species of tern, forage relatively close to breeding islands/colonies. This may lead to impacts upon foraging seabirds in the offshore environment, however, this is not expected to result in a threat to the overall population viability, given the relatively broad distributions of the seabird species.
Submerged Shoals and Banks[7]	**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. Satellite tracking of individual green turtles in the nearshore environment of the NWS did not indicate any overlap of the tracked post-nesting migratory routes and the Operational Area. 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 Glomar Shoals, Rankin Bank and Rowley Shoals. The potential impacts of exposure are as discussed previously in Offshore – Seasnakes. A hydrocarbon spill may disrupt a portion of the population but there is no threat to overall population viability. Seasnake species in Australia generally show strong habitat preferences (Heatwole and Cogger 1993); species that have preferred habitats associated with submerged shoals and oceanic atolls may be disproportionately affected by a hydrocarbon spill affecting such habitat.
	Sharks (including whale 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 Rankin Bank (Glomar Shoals and Rowley Shoals are not predicted to be contacted by entrained or dissolved hydrocarbons above threshold concentrations). 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

[7] The preceding discussion of protected species in the offshore environment is considered to be relevant to protected species associated with submerged shoals and banks. The text in this section is intended to provide additional context and impact assessment for protected species in relation to submerged banks and shoals.

	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 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.
Islands and Mainland (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 (refer to Section 4.3.4 and **Table 4-1** for the full list of EPBC listed cetacean species identified by the PMST search with potential to occur within the ZoC), coastal populations of small cetaceans and dugongs are known to reside or frequent nearshore waters, including the Ningaloo Coast, Muiron Islands, Montebello/Barrow/Lowendal Islands Group, Pilbara Southern and Northern Island Groups, Shark Bay, and a number of other nearshore and coastal locations including coastal areas of the Indonesian archipelago (see **Table 12-18**) which may be potentially impacted by surface, entrained and dissolved hydrocarbons exceeding threshold concentrations in the event of a loss of well containment. The predicted ZoC for surface, entrained and dissolved hydrocarbons extends past Exmouth Gulf and Shark Bay. These areas are known humpback whale aggregation areas during their annual southern migration (September to December); therefore, humpbacks moving into these aggregation areas may be exposed to hydrocarbons above thresholds levels. However, surface, entrained and dissolved hydrocarbons concentrations above thresholds are not expected within Exmouth Gulf itself. No hydrocarbon contact at or above threshold concentrations is expected for Camden Sound, an important calving area for humpback whales. 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. Hydrocarbon spill modelling indicates that surface hydrocarbons exceeding threshold concentrations may extend into the Lesser Sunda and Southern Java ecoregions of Indonesia, potentially exposing migratory and resident cetaceans and dugongs. The potential impacts from exposure to surface slicks are discussed above in Offshore – Cetaceans and Mainland and Islands (nearshore waters) – Cetaceans. Resident cetacean populations (e.g. numerous dolphin species) known to inhabit nearshore waters with the ZoC for surface hydrocarbons, such as the Laut Sawu Marine National Park, may experience impacts on feeding habitats that could disrupt a portion of the local population, but is not predicted to result in impacts on overall population viability of either dugongs or resident/coastal cetaceans. A hydrocarbon spill may disrupt a portion of a migratory cetacean population in Indonesian waters, including blue whale and sperm whale populations. 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) and, in rare circumstances, death. However, such disruptions or impacts are not predicted to impact on the overall population viability of migratory cetaceans within Indonesian waters. Therefore, a hydrocarbon spill may have an impact on feeding habitats and disrupt a significant portion of the local population, but 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 Houtman Abrolhos Islands Nature Reserve and Ngari Capes Marine Park, distant from the Operational Area but within the wider ZoC (**Table 12-18**). Given the considerable distance from the Operational Area to these receptors, and the lengthy time for surface and entrained hydrocarbons to contact (minimum 32 days for the Abrolhos Islands), surface or entrained hydrocarbons that do reach this area are likely to be weathered. Hydrocarbons accumulating on shorelines at haul out locations may result in oiling of sea lions. Oiling may inhibit the ability for sea lions to thermoregulate, potentially resulting in mortality through hypothermia. Oiled sea lions may also ingest hydrocarbons when attempting to clean themselves, potentially resulting in toxic effects.

	Marine Turtles Several marine turtle species utilise nearshore waters and shorelines for foraging and breeding (including inter nesting), with significant nesting beaches along the mainland coast and islands in potentially impacted locations such as the Ningaloo Coast, Muiron Islands, Montebello/Barrow/ Lowendal Islands Group, Pilbara Islands (Northern and Southern Island Groups), Shark Bay, Scott Reef, Ashmore Reef and the southern Indonesian archipelago. There are distinct breeding seasons as detailed in Section 4.3.4. The nearshore waters of these turtle habitat areas may be exposed to surface, entrained or dissolved hydrocarbons exceeding threshold concentrations, and accumulated hydrocarbons above threshold concentrations. The behaviour and biology of marine turtles makes these species relatively vulnerable to population scale impacts compared to other fauna, such as dugongs. All species of marine turtles exhibit high nesting site fidelity by females, with gene flow between populations primarily mediated by movements of male turtles (FitzSimmons et al. 1997). Additionally, marine turtles rely on nesting beaches to reproduce, which makes them vulnerable to impacts from spilled hydrocarbon accumulations on shorelines through oiling of nesting females and emergent hatchlings, and disturbance of nests from spill response activities (Lauritsen et al. 2017). A spill during nesting and hatching season poses an increased risk to marine turtle populations. A number of BIAs have been identified for marine turtles, including nesting, inter nesting and foraging areas. A hydrocarbon spill above impact thresholds in these areas may result in impacts to biologically important behaviours. 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 of some marine turtle species. The islands within the Lesser Sunda and Southern Java Ecoregions provide habitat for marine turtles, with the Laut Sawu Marine National Park in particular identified as providing habitat for five species of marine turtles – green, leatherback, olive ridley, loggerhead and flat back turtles. The potential impacts to marine turtles in Indonesian waters contacted by the surface hydrocarbon ZoC and those contacted by accumulated hydrocarbons on shorelines are likely to be similar to those described above for Offshore – Marine Turtles and Mainland and Islands (nearshore waters) – Marine Turtles. The potential impacts of exposure are as discussed previously in Offshore – Marine Turtles. In the nearshore environment, turtles can ingest hydrocarbons when feeding (e.g. on oiled seagrass stands/macroalgae), or can be indirectly affected by loss of food source (e.g. seagrass due to dieback from hydrocarbon exposure) (Gagnon and Rawson 2010). In addition, hydrocarbon exposure can impact turtles during the breeding season at nesting beaches. Contact with gravid adult females or hatchlings may occur on nesting beaches (accumulated hydrocarbons) or in nearshore waters (entrained hydrocarbons) where hydrocarbons are predicted to make shoreline contact. Results from studies of nesting beaches subject to extensive oil pollution from the Deepwater Horizon spill indicated a significant reduction (approximately 44%) in turtle nest density during the nesting season immediately following the spill (Lauritsen et al. 2017). Lauritsen et al. (2017) partially attributed this reduction to direct (e.g. direct mortality of adults due to oiling or toxicity) and indirect (e.g. shoreline disturbance from response activities) impacts from the spill. There was a significant increase in nesting density in the years immediately following the spill, with nesting density returning to levels comparable to pre-spill densities within two nesting seasons (Lauritsen et al. 2017). This indicates that adult female turtles that avoided mortality may have deferred nesting during the spill until subsequent years. The significant decline in nesting density observed following the Deepwater Horizon spill represents a decline of approximately 36% of reproductive output of the turtle population in the study area (Lauritsen et al. 2017); given turtles may take over a decade to reach sexual maturity, the effects of such a reduction in reproductive output may take over a decade to appear in nesting related metrics (which are commonly used to monitor turtle populations). Based on the deterministic modelling results and the potential for impact and recovery of turtles, a worst-case hydrocarbon spill from a loss of well containment may result in reduced turtle numbers and nesting density; however, it would not be expected to result in elimination of a population. Impacts and subsequent recovery may take decades to occur. To date, no oil spills have been demonstrated to have resulted in elimination of a turtle population at any scale (Yender and Mearns 2010). Disastrous spills impacting important turtle habitat (including nesting areas) have not been shown to eliminate turtle populations, although direct and indirect impacts have been documented (e.g. Lauritsen et al. 2017, McDonald et al. 2017, Stacy et al. 2017, Vander Zanden et al. 2016). Turtle populations have been shown to be able to recover, even when populations have been reduced to small sizes after experiencing significant declines (Mazaris et al. 2017). As such, population scale impacts to marine turtles from a worst-case loss of well containment would be expected to exhibit recovery, although may take several decades to reach pre-impact population levels due to the relatively long lifespan and late sexual maturity of marine turtle species

	Seasnakes Impacts to sea snakes for the mainland and island nearshore waters from direct contact with hydrocarbons may occur and may include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation 2011a). Refer to **Table 12-18** for relevant receptor locations for seasnakes predicted to be contacted by hydrocarbons above threshold concentrations
	Sharks (including whale 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). The Indonesian islands of Komodo and Nusa Penida, Bali are also known to host significant manta ray populations. 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 worst affected spill areas to ingest potentially toxic amounts of surface, 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 displace 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 surface, entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are fish eggs and phytoplankton 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 identified in Section 4.3.4) 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. **Table 12-18** 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 the overall viability of the population.
	Seabirds and/or Migratory Shorebirds In the unlikely event of a major spill, 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 surface, entrained and dissolved hydrocarbons. This could result in lethal or sublethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in waters near their breeding colony. This results in relatively higher seabird densities in these areas during the breeding season, 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 sublethal will depend on the weathering stage and its inherent toxicity. 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. Important areas for foraging seabirds and migratory shorebirds are identified in **Section 4.3.4**. Refer to **Table 12-18** for locations within the predicted extent of the ZoC that are identified as habitat for seabirds/migratory shorebirds. 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 and South Island Group; • Shark Bay; • Abrolhos Islands; and • Ashmore Reef. 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 Fish Populations** 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, so 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 hydrocarbon 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 polycyclic aromatic hydrocarbon (PAH) concentrations (Hjermann et al. 2007), which are typically the most toxic components of hydrocarbons. Light molecular weight aromatic hydrocarbons (i.e. one- and two-ring molecules) are generally soluble in water, which increases bioavailability to gill-breathing organisms such as fish. 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 in early life stages to hydrocarbons include disruption to complex behaviours 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. The Continental Slope Demersal Fish Communities KEF overlaps the Operational Area. The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF also overlaps the Operational Area, which has been shown to host demersal fish (BMT Oceanica 2016). Additionally, demersal species are associated with the Ancient Coastline KEF (approximately 19 km from the Operational Area) and Rankin Bank (approximately 238 km north-east of the Operational Area). These KEFs may host relatively diverse or abundant fish assemblages compared to relatively featureless continental shelf habitats. 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**
Submerged Shoals	The waters overlying the submerged Rankin Bank have the potential to be exposed to entrained hydrocarbons above threshold concentrations (at or greater than 500 ppb). This permanently submerged habitat represents sensitive open water benthic community receptors, extending from deep depths to relatively shallow water. Given the depth of Rankin Bank, it is likely the potential for biological impact is significantly reduced when compared to the upper water column layers. However, potential biological impacts could include 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. Glomar Shoals and Rowley Shoals) are not predicted to be exposed to entrained or dissolved hydrocarbons above threshold concentrations, but may be exposed to floating hydrocarbons above impact thresholds (**Table 12-18**). Although the waters above these shoals may be contacted by surface slicks, any entrainment of surface hydrocarbons is likely to be restricted to the first few metres of the water column and is considered to pose limited potential for impact to marine primary producer habitats at these locations.
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 12-18**) such as the Muiron Islands, Montebello / Barrow / Lowendal Islands Group, Pilbara Southern Islands Group, Rowley Shoals, Shark Bay and Abrolhos Islands. 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 12-18**). 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 / Lowendal Islands, Pilbara Southern and Northern Island Groups and Abrolhos Islands) 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 fertilization 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 / Lowendal Islands, Shark Bay, the Pilbara Southern Island Group (documented as low and patchy cover), the Northern Island Group and the Abrolhos Islands have the potential to be exposed (see **Table 12-18** 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. (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 10.1 days (Barrow Island); minimum time to contact with Shark Bay (which hosts ecologically significant seagrass communities) is 43.6 days. 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. Mangrove habitat and associated mud flats and salt marsh at Ningaloo Coast (small habitat areas) and the Montebello Islands have the potential to be exposed to entrained hydrocarbons (see **Table**

	12-18 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 mangrove habitat 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.
Indonesia	**Coral Reef** The fringing coral reefs of the islands of the Lesser Sunda and Southern Java ecoregions may be impacted by surface and accumulated hydrocarbons at or above threshold levels in the event of loss of well containment. The potential impacts on shallow water coral reef systems are discussed above for Mainlands and Islands (nearshore waters) – Coral Reef. There is the potential for lethal impacts due to the physical hydrocarbon coating of coral reef systems, with likely mortality of corals (adults, juveniles and established recruits) at areas contacted by surface hydrocarbons above threshold concentrations.
	Seagrass Beds/Macroalgae and Mangroves Seagrass meadows, macroalgae and mangroves in the intertidal and subtidal habitats of the islands of the Lesser Sunda and Southern Java ecoregions all have the potential to be contacted by surface hydrocarbons exceeding threshold levels, in the unlikely event of a loss of well containment. The potential impacts on these habitats and communities are discussed above for Mainland and Islands (nearshore waters).
Summary of potential impacts to other habitats and communities	
Setting	**Receptor Group**
Offshore	**Benthic Fauna Communities** In the event of a major release at the seabed, the stochastic spill model predicted hydrocarbons droplets would be entrained, rapidly transporting them to the sea surface. As a result, the low sensitivity benthic communities associated with the unconsolidated, soft sediment habitat and any epifauna (filter feeders) associated with the Enfield Canyon (part of the Canyons KEF, and the Continental Slope Demersal Fish Communities KEF) within and outside the Operational Area are not expected to have widespread exposure to released hydrocarbons. Impacts are expected to be restricted to a localised area relating to the hydrocarbon plume at the point of release, which would result in a small area of seabed and associated epifauna and infauna exposed to hydrocarbons. Heterotrophic, filter feeding organisms, such as sponges and gorgonians, have been identified as potentially occurring in the canyon features located within the wider ZoC. In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of hydrocarbon would form droplets that would be transported into the water column to the surface (i.e. transported away from the seabed). As a result, hydrocarbon exposure to these deep-water filter-feeding communities is unlikely, and exposure at concentrations of ecological consequence is not expected to occur where these heterotrophic communities exist. Evidence from the Deepwater Horizon spill in the Gulf of Mexico recorded low taxa richness and high nematode/harpacticoid-copepod ratios within 3 km of the release location and moderate impacts up to 17 km away (Montagna et al. 2013). The communities were likely exposed to dispersed hydrocarbons as the response included subsea dispersant application. A loss in benthic biodiversity has been correlated to a decline in deep-water ecosystem functioning (Danovaro et al. 2008). The location of the petroleum activity and the ZoC largely affect continental shelf waters, which are shallower than the Deepwater Horizon spill, and as such may host more diverse infauna communities, although the impacts are considered to be similar. Therefore, a loss of well containment may result in localised but long-term effects on community structure.

	Open Water – Productivity/Upwelling Primary production by plankton (triggered by sporadic upwelling events in the offshore waters) is an important component of the primary marine food web. Planktonic communities are generally mixed, including phytoplankton (cyanobacteria and other microalgae), secondary consuming zooplankton (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 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 surface, 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 are likely to be short-term and restricted to planktonic communities close to the release location.
	Open Water – Physical Displacement of Fauna from Oil and Gas Plume A worst-case loss of well containment will release significant quantities of gas and liquid hydrocarbons, which will form a plume that rapidly moves upwards in the water column. The effect of the physical extent of the oil and gas plume in the environment is expected to have a limited and localised effect on identified receptors, such as the physical barrier created by the oil and gas plume, which may displace transient and/or mobile biota such as pelagic fish, megafauna species (migratory whales) and plankton. The plume will act to entrain oil, which may then extend considerable distances from the release location (as discussed in impact assessments for other receptors). It is acknowledged that the physical extent of the plume may displace some open water species transiting the offshore waters of this area of the NWS. The extent of the plume is relatively small in comparison to the surrounding offshore environment, but the overall impact to the in-water biota and the marine environment in general is expected to be slight to minor short-term impact to communities present in the ZoC.
Submerged Shoals	**Open Water – Productivity/Upwelling** The submerged shoals of Rankin Bank are areas associated with sporadic upwelling and associated primary productivity events. Stochastic spill model results predict entrained hydrocarbons (at or above the 500 ppb threshold) may reach Rankin Bank. 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 temporary and localised at the shoals.
	Filter Feeders Hydrocarbon exposure may occur to offshore filter-feeding communities (e.g. communities around Rankin Bank in water depths between 80–100 m or on hard substrate associated with the Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF and Continental Slope Demersal Fish Communities KEF or other locations as identified in **Table 12-18**), depending on the depth of the entrained/dissolved hydrocarbons. Exposure to entrained hydrocarbons/dissolved aromatic hydrocarbons (≥500 ppb) has the 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.
Islands and Mainland (Nearshore Waters)	**Open Water – Productivity/Upwelling** Nearshore waters and adjacent offshore waters surrounding the offshore islands (e.g. Muiron Islands, Montebello/Barrow/Lowendal Islands Group) 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 temporary and on exposed planktonic communities present in the ZoC..

	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 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 such as snapper and mackerel) 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 or dissolved hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters, including Ningaloo Coast, the Muiron Islands, Montebello/Barrow/Lowendal Islands Group, Pilbara Southern and Northern Islands Groups, Shark Bay and the Abrolhos Islands. This has the potential to result in lethal and sublethal impacts to a portion of fish larvae in areas contaminated above impact thresholds, 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 supported by 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. 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.
	Non-biogenic Reefs The reef communities fringing the Pilbara region (e.g. Pilbara islands) may be exposed to surface or entrained hydrocarbons (at or above threshold concentrations), and consequently exhibit lethal or sub lethal impacts resulting in partial or total mortality of keystone sessile benthos, particularly hard corals; thus, potential community structural changes to these shallow, nearshore benthic communities may occur. If these reefs are exposed to entrained or dissolved hydrocarbons, impacts are expected to result in localised long-term effects.
	Offshore Filter Feeders Hydrocarbon exposure to filter-feeding communities (e.g. deep-water communities of Ningaloo coast and the Muiron Islands in 20–200 m) may occur, depending on the depth of the entrained and dissolved aromatic hydrocarbons. See discussion above on potential impacts.
	Nearshore Filter Feeders Nearshore filter feeders that are present in shallower water <20 m may potentially be impacted by entrained hydrocarbon through lethal/sub-lethal effects (see discussion for Offshore Filter Feeders). Nearshore filter feeder communities identified within the Jurien CMP (approximately 959 km from the Operational Area) may be exposed to hydrocarbons. Such impacts may result in localised, long term effects to community structure and habitat.
	Sandy Shores/Estuaries/Tributaries/Creeks (Including Mudflats)/Rocky Shores Shoreline exposure for the upper and lower areas differ. The upper shore has the potential to be exposed to surface slicks, while the lower shore is subjected to dissolved or entrained oil. Potential impacts may occur due to surface hydrocarbon contact with intertidal areas, including sandy shores, mudflats and rocky shores. Hydrocarbons at sandy shores are incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores (International Petroleum Industry Environmental Conservation Association 2000). Hydrocarbons in the intertidal zone can adhere to sand particles; however, high tide may remove some or most of the hydrocarbons back out of the sediments. Typically, hydrocarbons are only incorporated into the surface layers to a maximum of 10 cm (International Petroleum Industry Environmental Conservation Association 2000). It is predicted that a number of sandy shores along the coastline may have accumulated hydrocarbons ≥100 g/m^2 (see **Table 12-18).** As described earlier, accumulated hydrocarbons ≥100 g/m^2 could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat. The persistence of the hydrocarbons will be dependent on the wave exposure, but can be months to years. The impact of oil on rocky shores is 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 oil (International Petroleum Industry Environmental Conservation Association 2000). 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/m2 could coat the epifauna along rocky coasts and impact the reproductive capacity and survival. The location of rocky shores where impacts are predicted are listed in **Table 12-18**. Intertidal mudflats are susceptible to potential impacts from hydrocarbons, as they are typically low energy environments and therefore trap oils. Intertidal mudflats have been identified in the ZoC along the Ningaloo coast, Pilbara coastline and as far north as Indonesia (see **Table 12-18**). 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 oil will penetrate the water-saturated sediments. However, oil can penetrate fine sediments through animal burrows and root pores. It has been demonstrated that infaunal burrows allow hydrocarbons to enter subsurface sediments, where it can be retained for months. The toxicity of stranded surface hydrocarbons and the in-water toxicity of the entrained or dissolved hydrocarbons reaching the shorelines, identified in **Table 12-18**, will determine impacts to 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 or dissolved 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).
Indonesia	**Open Water – Productivity/Upwelling** Floating hydrocarbons are the only fraction identified by stochastic modelling as potentially reaching Indonesian waters above impact thresholds. Given the distance between the release location and sensitivities in Indonesia, any hydrocarbons reaching Indonesian waters will be highly weathered. The majority of soluble and volatile components of the hydrocarbon will have been lost prior to reaching Indonesian waters. The Lesser Sunda and Southern Java ecoregions of Indonesia experience seasonal upwellings that support megafauna such as migratory cetacean species. The potential impacts to cetaceans from surface hydrocarbons are discussed above in Offshore – Cetaceans and Mainland and Islands (nearshore waters) – Cetaceans. Mantra rays and whale sharks attracted to seasonal upwellings may experience indirect impacts if the spill was to coincide with a seasonal event such as plankton aggregations. However, surface slicks that have not entered the water column by entrainment or dissolution are unlikely to have a significant impact on plankton populations, as only a small proportion of the population will be close to the surface. The main pathways for direct exposure and contamination of plankton are digestion and transport of hydrocarbon particles through the gut (Gajbhiye et al. 1995), and exposure to OIW emulsions which adhere to the external body wall or gills. Both these pathways are unlikely to result from surface hydrocarbons. Therefore, significant impacts on open water productivity and upwelling in Indonesian waters are unlikely.

	Spawning/Nursery Areas As discussed for Indonesia – Pelagic Fish, there is the potential for intertidal nursery areas such as mangroves and seagrass meadows to be contacted by surface hydrocarbons at or above threshold concentrations, potentially leading to impacts such as smothering of mangroves and seagrasses. Impacts to mangroves and seagrasses may result in indirect impacts to early life stages of marine fauna species (such as fish species targeted by local fishers) using these habitats. Given the nature of the hydrocarbon (highly weathered, soluble and volatile components significantly diminished, etc.) and the sporadic nature of shoreline/shallow water contact, impacts are expected to be localised, with no population- or ecosystem-scale impacts expected.
	Nearshore Filter Feeders Potential impacts to nearshore filter feeders in Indonesian waters are unlikely, given the lack of entrained or dissolved hydrocarbons, and the limited potential for surface slicks to entrain into the water column.
	Sandy Shores/Estuaries/Tributaries/Creeks (including Mudflats)/Rocky Shores The islands of the Lesser Sunda and Southern Java ecoregions have the potential to be contacted by surface hydrocarbons and accumulated hydrocarbons above threshold levels. The potential impacts to shoreline habitats are discussed above for Mainland and Islands (nearshore waters) – Sandy Shores/Estuaries/Tributaries/Creeks (including mudflats)/Rock Shores. Prolonged stranding of surface hydrocarbons, particularly for low energy environments such as mudflats, may lead to localised changes to the community structure of these shoreline habitats (International Tanker Owners Pollution Federation 2011a) which would be expected to recover in the medium term (2–5 years).
Key Ecological Features	**Key Ecological Features** KEFs potentially impacted by the hydrocarbon spill from a loss of well containment event are provided in **Table 4-2.** 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 event are predicted to result in moderate impacts to values of the KEFs affected. Potential impacts include contamination of sediments, impacts to benthic sediment fauna 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. KEFs within the ZoC that are not associated with broad-scale distributions (i.e. Glomar Shoals, Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals) are not expected to be impacted by floating hydrocarbons, and contact with entrained and dissolved fractions is predicted to be very low/no contact. Hence, the environmental values of these KEFs are not expected to be impacted upon.
Summary of potential impacts to water quality	
Setting	***Aspect***
Offshore and Mainland and Islands (Nearshore waters)	**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 each of the 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 compared to background water quality.
Summary of potential impacts to marine sediment quality	
Setting	***Receptor Group***
Offshore	**Marine Sediment Quality** Studies of hydrocarbon concentrations in deep sea sediments in the vicinity of a catastrophic well blowout indicated hydrocarbon from the blowouts can be incorporated into sediments (Romero et al. 2015). Proposed mechanisms for hydrocarbon contamination of sediments include sedimentation of hydrocarbons and direct contact between submerged plumes and the seabed (Romero et al. 2015). In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of hydrocarbon would form droplets that would be transported into the water column to the surface (i.e. transported away from the seabed). As a result, the extent of potential impacts to the seabed area at and surrounding the release site would be largely confined to a localised footprint.

	Marine sediment quality would be reduced as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term, as hydrocarbons in sediments typically undergo slower weathering and degradation (Diercks et al. 2010, Liu et al. 2012). There is the potential for floating and entrained hydrocarbons to sink following extensive weathering and adsorption of sediment particles, which may result in the deposition of hydrocarbons to the seabed in areas distant from the release location. Such hydrocarbons are expected to be less toxic due to the weathering process.
Mainland and Islands (Nearshore waters)	**Marine Sediment Quality** Floating, entrained and dissolved hydrocarbons (at or above the defined thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines. Hydrocarbons may accumulate (at or above the ecological threshold) at a range of nearshore receptors (refer to **Table 12-18**). 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 has the potential to result in short term reduction in air quality. Potential impacts are expected to be a minor and short term effects to ecosystems, species and/or habitats in the area. There is potential for human health effects on workers in the immediate vicinity of atmospheric emissions. The ambient concentrations of 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. VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. Due to the unlikely occurrence of a well loss of containment, the temporary nature of any VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment), the predicted behaviour and fate of VOCs in open offshore environments, and the significant distance from the Operational Area to the nearest sensitive air shed (town of Exmouth approximately 51 km away), the potential impacts are expected to be minor and short term.	
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 **Table 12-18** may be affected by the released hydrocarbons. In the unlikely event of a major spill, entrained 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 12-18**). There is also the potential for the following Indonesian Marine National Parks and National Parks to be contacted by surface and accumulated hydrocarbons at or above threshold levels: • Laut Sawu Marine National Park; and • Tanjung Tampa Nature Recreation Park. Impact on the protected areas is discussed in the sections above for ecological 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 biologically diverse environments.	
Summary of potential impacts to socio-economic values	
Setting	**Receptor Group**
Offshore	**Fisheries – Commercial** Spill scenarios that were modelled may cause significant direct impacts on the target species of Commonwealth and offshore State fisheries within the defined ZoC. Further details are provided below (the impact assessment relating to spawning is discussed above under 'Summary of Potential Impacts to Other Habitats and Communities'). ***Southern Bluefin Tuna, Skipjack Tuna, Western Tuna and Billfish, Small Pelagic, Southern and Eastern Scalefish and Shark Fisheries*** The tuna and small pelagic fisheries target pelagic fish species. Adult fish are highly mobile and able to move away from the spill affected area or avoid the surface waters; however, hydrocarbon concentrations in the upper water column could lead to potential exposure through direct absorption of hydrocarbons, and indirectly by the consumption of contaminated prey (Merkel et al. 2012). Given these pelagic species are distributed over a wide geographical area, the impacts at the population or species level are considered minor in the unlikely event of a spill. A major loss of hydrocarbon from

	the Petroleum Activities Program may lead to an exclusion of fishing from the spill affected area for an extended period. ***North West Slope and Western Deepwater Trawl Fisheries*** The predicted ZoC resulting from an uncontrolled loss of hydrocarbon from a loss of well containment may result in direct impacts on the species fished by the North West Slope Trawl Fishery and Western Deep Trawl Fishery. These fisheries target benthic species (demersal finfish and crustaceans) in water greater than 200 m deep. The Northwest Slope Trawl Fishery targets scampi and deep-water prawns. These species are less mobile and will therefore not be able to easily move away from the location of a well blowout. Mortality/sub lethal effects may impact populations located close to the well blowout location. Mortality and sub lethal effects may impact localised populations of targeted species close to the well blow out and within the ZoC for entrained/dissolved hydrocarbons (≥ 500 ppb). However, the entrained hydrocarbon is likely to be confined in the upper water column, therefore the demersal species are less likely to be exposed to hydrocarbons than pelagic species. This is particularly relevant, as the majority of the fishing effort for both these fisheries is located distant from the location of a potential well blowout. Exploited fish resources in these areas are less likely to be impacted significantly, as hydrocarbons at this distance are likely to be confined in the upper water column. A major loss of hydrocarbons from the Petroleum Activities Program may lead to an exclusion of fishing from the spill affected area for an extended period. ***State Fisheries*** Hydrocarbons from a major spill may impact on the area fished by a number of State fisheries within the ZoC . These fisheries generally use a range of gear types (trawl, trap and line), and operate from shallow inshore water to water depths up to 200 m, targeting demersal and pelagic finfish species and prawns. In the unlikely event of a major hydrocarbon spill, there is the potential for the targeted fish species to be exposed to entrained and/or dissolved aromatic hydrocarbons in the water column. However, the potential for direct impact would be reduced, as target species such as mackerel and snapper are likely to avoid the surface water layer underneath oil slicks. Demersal species (such as finfish and crustaceans) have limited mobility, and therefore will not be able to easily move away from a spill. Mortality/sub lethal effects may impact populations located close to the well blowout location. The demersal and crustacean (prawn) fisheries are located over 20 km from the location of a potential well blowout. Populations in these areas are less likely to be impacted significantly, as hydrocarbons at this distance are likely to be entrained/dissolved or weathered and confined in the upper water column. A major loss of hydrocarbons from the Petroleum Activities Program may lead to an exclusion of fishing from the spill affected area for an extended period. A number of other State and Commonwealth fisheries, further afield in the ZoC, may also be affected by a major spill; however, the impacts to these far field fisheries will be similar to those described below for ‘General Fisheries Impacts’. ***General Fisheries Impacts*** 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 an exclusion zone around the spill affected area. There would be a temporary prohibition on fishing activities for a period of time, and subsequent potential for economic impacts to affected commercial fishing operators.
	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) for the Exmouth region. Limited recreational fishing takes place in the offshore waters of the Operational Area. Impacts on species that are recreationally fished are described above under ‘Summary of Potential Impacts to Other Species’. A major loss of hydrocarbons from the Petroleum Activities Program may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for operators. Tourism is a major industry for the region, and visitor numbers would likely reduce if a hydrocarbon spill were to occur based on the perception of hydrocarbon spills and associated impacts resulting in moderate, medium term (5–10 years) impacts to community and highly valued areas

	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), as well as activities such as drilling and seismic exploration. 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 offtake tankers approaching facilities off the North West Cape. 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 production is the Nganhurra FPSO (operated by Woodside). Other nearby facilities include the Quadrant operated Ningaloo Vision FPSO and the BHP operated Pyrenees Venture FPSO. Operation of these facilities is likely to be affected in the event of a well blowout spill.
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, Glomar Shoals 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 could be affected, including pearl aquaculture in the North West Cape (including Exmouth Gulf) and wild oysters in the Pearl Oyster Managed Fishery that are within the nearfield ZoC, and further afield the Western Rock Lobster Fishery and a number of west coast and south coast fisheries). Targeted fish, prawn, mollusc and lobster species and pearl oysters could experience sub-lethal stress, or in some instances mortality, depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. In addition, there is also the potential for commercial and artisanal Indonesian fisheries and aquaculture (e.g. seaweed farming) to be impacted (see above for potential impacts to seagrasses). ***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 have the potential to impact prawn stocks. For example, juvenile banana prawns are found almost exclusively in mangrove-lined creeks (Rönnbäck et al. 2002), 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, a range of subtidal habitats that support juvenile prawns may be exposed to hydrocarbons above impact thresholds, including: • Muiron Islands; • Montebello Islands; • Barrow Island; • Lowendal Islands; • Pilbara Northern and Southern Island Groups; • Shark Bay; and • Ningaloo Coast. Localised loss of juvenile prawns in worst 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 The wider ZoC intersects the formally recognised “MoU Box” covering Scott Reef and surrounds, Seringapatam Reef and Ashmore Reef. Indonesian traditional fishers target trochus, sea cucumbers

	(holothurians), abalone, green snail, sponges, giant clams and finfish, including sharks. Impacts would be similar to those identified for commercial fishing, in the form of a potential exclusion zone and contamination/tainting of fish stocks. This may result in discarding of catch, or reduced fishing effort due to fishery closure.
	Tourism and recreation In the unlikely event of a major spill, the nearshore waters of the Ningaloo coast and shorelines further south and north (including Indonesia) could be reached by surface slicks, entrained hydrocarbons and dissolved hydrocarbons, depending on prevailing wind and current conditions. As these locations offer a number of amenities such as fishing, swimming and using beaches and surrounds, they have a recreational value for local residents and visitors (regional, national and international). If a well blowout event resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering, tides, currents or oil spill response (e.g. shoreline clean-up if safe to do so) removes the hydrocarbons. In the event of a well blowout, tourists and recreational users may also avoid areas due to perceived impacts, including after the oil spill has dispersed. Typically, a hydrocarbon spill that results in visible slicks in coastal waters and on shorelines will disrupt recreational activities, particularly tourism and its supporting services. In the unlikely event of a well blowout, hydrocarbons may accumulate on shorelines (at or above a set threshold), and there is potential for visible surface slicks (<10 g/m2) (i.e. a rainbow sheen) to reach sensitive receptor locations, for example, key tourist areas of the Ningaloo Coast (see **Table 12-18** for the full list of receptors). As a result of surface slicks in nearshore waters and potential accumulation on beaches, it is expected that there will be a temporary cessation of all marine-based tourism activities on the spill-affected coast and wider coastal area for a period of weeks or longer, until natural weathering or tides and currents remove the hydrocarbons or clean-up operations remove beached oil. There is the potential for stakeholder perception that this 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 A number of historic shipwrecks have been identified in the vicinity of North West Cape. The spill results do not predict surface slicks contacting the identified wrecks. However, shipwrecks occurring in the subtidal zone will be exposed to entrained/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 large fish species moving away, and/or resident fish species and sessile benthos such as hard corals exhibiting sub-lethal and lethal impacts (which may range from physiological issues to mortality). The foreshore and hinterland of North West Cape and along the coastline to Shark Bay contain numerous Aboriginal sites such as burial grounds, middens and fish traps. Only sites that are located below the high water mark are expected to be impacted from a spill. This could result in hydrocarbon contamination of the site, which may affect the cultural significance and traditional practices associated with the sites. Within the wider ZoC are a number of designated heritage places (Section 4.4). These places are also covered by other designations such as World Heritage Area, Marine Park and Listed Shipwreck. Potential impacts have therefore been discussed in the sections above.
Indonesia	**Fisheries – Traditional** The Lesser Sunda and Southern Java ecoregions of Indonesia are a productive area for Indonesian artisanal fisheries. The potential impacts to these fisheries from surface hydrocarbons at or above threshold levels would be similar to those described above for Offshore and Mainland and Islands traditional and commercial fisheries, and would be likely to include exclusion zones and the potential tainting/contamination of catch. Indirect impacts may include impacts to local economies of coastal communities.
	Aquaculture Within the Lesser Sunda and Southern Java ecoregions, aquaculture, encompassing a variety of species and methods, contributes significantly to local employment and food production. The main species farmed are seaweed, prawns and fish. If surface hydrocarbons at or above threshold levels contact aquaculture operations, impacts are likely to include shutdown of production, contamination/

	tainting of product, and, in the case of seagrass potentially exposed at low tides, smothering and dieback. Indirect impacts are likely to include loss of income and economic impacts to coastal communities.
	Tourism and Recreation Tourism is a major industry within the Lesser Sunda and Southern Java ecoregions, with the islands of Bali, Flores, Lombok, Komodo and the Gili Islands particularly important popular tourist destinations, with beach and coastal activities primary attractions. Contact with surface or accumulated hydrocarbons above threshold levels with these areas is likely to result in similar impacts to those described above for Mainland and Islands (nearshore waters) – Tourism and Recreation and would include restricted access to beaches for a period of days to weeks or longer, and the potential for tourist perception that this environment will be contaminated over a large area and for the longer term. This could result in a potential prolonged period of tourism decline. Indirect impacts are likely to include loss of income and economic disruption to a portion of the Lesser Sunda and Southern Java ecoregions.

Summary of Control Measures

- Maintain well mechanical integrity to contain reservoir fluids within the well envelope to avoid a MEE. Integrity will be managed with the following SCE technical performance standards:
  - P10 – wells
  - P28 – Sand management system.
- Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed with the following SCE technical performance standard:
  - E04 - Safety Critical Communication Systems.
- Maintain Safety Instrumented System (Safety Instrumented Functions and ESD actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition so as to prevent or mitigate the effects of a MEE. Integrity will be managed with the following SCE technical performance standards:
  - F06 – ESD System
  - P10 – Wells.
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure (Section 6.1.5.2) and the following SCE technical Performance Standard:
  - E05 - Environmental Incident Response Equipment.
- Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011: Accepted WOMP.
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility.
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Subsea Flowline and Riser Loss of Containment (MEE-02)

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	Risk Rating	ALARP Tools	Acceptability
Loss of hydrocarbons to the marine environment due to a subsea flowline and riser loss of containment (GE).		X	X		X	X	X	B	B	2	H	LCS GP PJ RBA CV SV	Acceptable if ALARP
Loss of hydrocarbons to the marine environment due to a subsea flowline and riser loss of containment (Vincent).		X	X		X	X	X	B	C	1	M		
Description of Source of Risk													

Background

The Vincent field subsea systems comprise two subsea production manifolds tied in to a total of thirteen subsea production trees. The Vincent subsea system also includes two water injector trees and one gas injector tree. There are two 250 mm flowlines extending from Vincent Field wells to the risers connected to the NY FPSO. The total riser capacity is two 250 mm production risers, one 250 mm water disposal riser and one 150 mm gas injection riser.

The GE production system comprises six production wells tied back to the NY FPSO via a 31 km 16" wet insulated carbon steel flowline. Flexible flowlines are used to gather production from the five individual Laverda Canyon (LC) and NOL wells and deliver the fluids to the suction side of a MPP. A Cimatti production well ties in via a flexible spool to a tee in the rigid flowline approximately 16.5 km (by flowline length) downstream of the MPP. This well uses gas for artificial lift. The GE subsea system also includes six water injector wells, as well as a water injector flowline and associated riser.

A subsea loss of containment from these components may result in minor weeps through to the release of large volumes of hydrocarbon inventory. Due to the potential consequences, a subsea flowline and riser loss of containment is considered to be an MEE (MEE-02). The potential hazard sources that could instigate a loss of containment from the NY flowlines and risers are:

- internal corrosion;
- external corrosion;
- erosion;
- overpressure or under pressure;
- low temperature
- equipment fatigue/stress;
- flowline stability and free spans;
- anchor impact/dragging; and
- loss of control of suspended load from visiting vessel.

Escalation from other MEEs can cause flowline and riser loss of containment:

- loss of structural integrity (MEE-06) (Section 5.8.8);
- loss of marine vessel separation (MEE-07) (Section 5.8.9); and
- loss of control of suspended load from facility lifting operations (MEE-08) (Section 5.8.10).

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties in Section 5.2.

Subsea Rigid Production Flowline and Riser Loss of Containment – Credible Scenarios

The credible worst-case subsea flowline and riser loss of containment scenario identified for the Petroleum Activities Program is a loss of hydrocarbons from the GE rigid production flowline. This is considered to be the worst-case release of all subsea flowlines and risers, as it contains the greatest volume (2200 m3 of GE crude, a mix of hydrocarbons from Norton, Laverda and Cimatti wells) of isolatable hydrocarbon in the subsea infrastructure. The loss of hydrocarbons from the GE rigid production flowline assumes complete loss of the inventory of the flowline over one hour, which is the time selected as a reasonable estimate for the NY FPSO to become aware of the leak and intervene to isolate the compromised infrastructure. The subsea flowline and riser loss of containment release characteristics are summarised in **Table 12-19**.

Table 12-19: Summary of worst-case subsea loss of containment hydrocarbon release scenarios

Scenario	Hydrocarbon	Duration (hrs)	Depth (m)	Latitude (D°M'S'' S)	Longitude (D°M'S'' E)	Total Release Volume (m^3)
Rigid production flowline and riser loss of containment	GE crude	1 hour	529	21° 26' 24" S	113° 57' 55" E	2200

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in subsea production system design, construction and operation. In the company's 60-year history, it has not experienced any subsea infrastructure integrity events that have resulted significant environmental impacts. The NY facility has never experienced a worst-case subsea flowline and riser loss of containment in its operational history.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons as a result subsea flowline and riser loss of containment is considered an MEE (MEE 02). The hazard associated with this MEE is hydrocarbons in subsea flowlines and risers..

Quantitative Spill Risk Assessment

Spill modelling of worst case credible subsea flowline and riser loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulation was a release based on the assumptions in **Section 5.4**. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volume for a subsea flowline and riser loss of containment.

Hydrocarbon Characteristics

Norton-1 crude was selected as the hydrocarbon type for the release scenario. It is considered consistent with a worst-case release due to the persistent nature of the hydrocarbon. Refer to the MEE-01 and MEE-03 for the characteristics of Norton-1 crude.

Subsea Plume Dynamics

The loss of hydrocarbons from the GE rigid production flowline will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, infrastructure marked on marine charts), the likelihood has been taken as 2 (Unlikely). Woodside has also considered industry data for pipeline and riser release frequencies in informing the likelihood assessment (PARLOC 2012). This data indicates a large loss of containment from a flowline with similar attributes as the GE flowline (i.e. material, length and diameter) could occur once every 1000 to 10,000 years. Such a release frequency also corresponds to a 2 (Unlikely) on the Woodside Risk Matrix

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case subsea or riser loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (MEE-03) and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts to Marine Sediment, Water Quality, Air Quality, Ecosystems / Habitats, Species and Socio-Economic Environment

Zone of Consequence

Surface Hydrocarbons

As described in Section 5.4, the ZoC depicted in these figures are a summary of all the locations where environmental thresholds could be exceeded for the modelled scenario.

The modelled floating hydrocarbons from the loss of hydrocarbons from the GE rigid production flowline are forecast to drift in all directions (primarily along a southwest-northeast axis), reflecting the competing influence of both surface currents and winds across the wide area in which a slick could travel. At the surface threshold of 10 g/m2, floating oil is forecast to potentially occur up to approximately 1100 km from the release site. Contact above impact thresholds was forecast at several receptors (**Table 12-20**).

Entrained Hydrocarbons

Entrained hydrocarbons above impact thresholds are likely to drift south-west from the release location, then southwards along the Ningaloo Coast. Transport of entrained hydrocarbons reflects the prevailing current regime in the area. Entrained hydrocarbon concentrations above impact thresholds may occur up to 1000 km from the release location. Stochastic modelling results indicated contact above impact thresholds at a number of locations (**Table 12-20**).

Dissolved Hydrocarbons

In the event of a subsea flowline and riser loss of containment scenario occurring, stochastic modelling results indicated a plume of dissolved hydrocarbons would potentially behave as per the entrained hydrocarbon plume, due to the influence of the NWS prevailing currents. Stochastic modelling results indicated contact above impact thresholds may occur at a range of receptors (**Table 12-20**). Dissolved hydrocarbon concentrations above impact thresholds may occur up to 150 km from the release location.

Accumulated Hydrocarbons

No accumulation above impact thresholds from the loss of hydrocarbons from the GE rigid production flowline was predicted to occur along any shorelines.

Table 12-20: Zone of Consequence (ZoC) – key receptor locations and sensitivities with the summary hydrocarbon spill contact for a pipeline loss of containment (table cell values correspond to scenario numbers)

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate			
		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 deep water 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[8]	Commonwealth waters	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	
	Argo-Rowley Terrace CMP	✓						✓							✓	✓			✓			✓	✓	✓		✓			✓					✓
Oceanic Reefs and Offshore Islands	Clerke Reef and State Marine Park	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓					✓
	Imperieuse Reef and State Marine Park	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓					✓
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓			✓		
	Bernier and Dorre Islands	✓	✓	✓	✓		✓	✓			✓	✓		✓		✓			✓	✓		✓	✓	✓	✓	✓		✓	✓					✓

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

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate			
		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 deep water 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)
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓		✓	✓			✓	✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		✓			✓
	Shark Bay – WHA and Marine Park	✓	✓	✓	✓	✓	✓					✓		✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓			✓

Summary of Potential Impacts to environmental values(s)
Consequence Assessment Summary The credible worst-case hydrocarbon spill scenario that may arise from MEE-02 may impact upon a range of environmental receptors; refer to **Table 12-20** for a summary of receptors identified by the stochastic spill modelling studies. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01. The credible worst-case hydrocarbon volumes that can credibly be released by MEE-02 are significantly smaller than the credible worst-case loss of well containment volumes considered in MEE-01. Additionally, the credible release durations are significantly shorter.
Summary of Control Measures

• Maintain flowline, riser and hydrocarbon-containing infrastructure integrity to avoid a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  ○ F05 – ESD Valve
  ○ F06 – ESD System
  ○ P09 – Pipeline Systems
  ○ P23 – Mooring Systems
  ○ P28 – Sand management system
• Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed with the following SCE technical performance standards:
  ○ E04 - Safety Critical Communication Systems
• Maintain Fire and Gas Detection and Alarm Systems on GWA facility to facilitate prevention and response to fire or gas hazards. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard to prevent environment risk related Damage to SCEs for:
  ○ F01- Fire and Gas Detection and Alarm Systems
• Maintain Safety Instrumented System (Safety Instrumented Functions and ESD actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition (e.g through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  ○ F05 – ESD Valves
  ○ F06 – ESD System
  ○ P10 – Wells
• Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard to prevent environment risk related Damage to SCEs for:
  ○ E05 - Environmental Incident Response Equipment, including;
• Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility
• Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for NWS Pipelines
• Incident reports are raised for unplanned releases within event reporting system.
• Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Topside Loss of Containment (MEE-03)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon Release from Topsides Process Equipment to the Marine Environment and Atmosphere.		X	X	X		X	X	B	C	1	M	LC S GP PJ RB A CV SV	Acceptable if ALARP
Hydrocarbon Release from Topsides Non-Process Equipment to the Marine Environment.		X	X	X		X	X	B	D	3	M		

Description of Source of Risk

The NY Facility has a range of topsides process and non-process equipment within 11 pre-assembled modules. Release of process (i.e. gas and crude) and non-process hydrocarbons (of which diesel is the largest inventory) from the NY Facility topsides has the potential to release significant quantities of hydrocarbons to the marine environment. Hydrocarbon spill modelling for a 1000 m^3 release of processed crude oil as a result of an offloading hose rupture is discussed in MEE-04. The results of this modelling can be considered to be a very conservative estimate of the worst case topsides process loss of containment of rupture of the electrostatic coalescer, which holds a maximum isolatable inventory of 428 m^3 of oil. The potential impacts of the topsides process release are therefore, discussed in MEE 04.

The following hazards could lead to loss of containment from the NY FPSO topsides:

- internal corrosion;
- external corrosion;
- erosion;
- overpressure;
- low temperature;
- overstress of topsides equipment;
- equipment fatigue; and
- rotating equipment failure / uncontrolled transfer.

Escalation from other MEEs can cause topsides loss of containment:

- loss of structural integrity (MEE-06);
- loss of marine vessel separation (MEE-07) ; and
- loss of control of suspended load from facility lifting operations (MEE-08).

Topsides Loss of Containment – Credible Scenarios

The worst case credible topsides process release scenario is a loss of containment of approximately 428 m^3 of crude oil from the electrostatic coalescer. A release due to this scenario was modelled, as the release from an offtake hose loss of containment (MEE-04) (1000 m^3) was used to inform the risk assessment. Refer to MEE-04 for an assessment of a surface release of crude oil.

The worst case credible non-process release from NY is a loss of containment of the diesel oil settling tank. This tank has a maximum inventory of approximately 197 m^3. Woodside has commissioned modelling for a number of diesel spills, including a 371 m^3 surface release of diesel at the location of the NY FPSO. This modelling has been used to inform the risk assessment of the diesel component of topsides diesel loss of containment scenario (197 m3). This is considered to be suitable given the consistent release location and hydrocarbon type. The modelled volume is larger than the credible diesel spill component, which is likely to overestimate the size of the spill, making the assessment inherently conservative.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons from a topsides process loss of containment is considered an MEE (MEE-03). The hazard associated with this MEE is hydrocarbons contained within topsides process equipment. Note that Woodside has assessed the environment consequence of a worst case credible loss of containment from topsides equipment as "C" as per the Woodside Risk Matrix. Woodside has also assessed the reputational and brand consequences associated with this release, and concluded that the event results in a "B" level consequence, and hence meets Woodside's definition of an MEE.

Quantitative Spill Risk Assessment

Stochastic hydrocarbon spill modelling for the offloading equipment loss of containment was used to inform the risk assessment for a topsides process loss of containment (refer to credible scenarios detailed above). Stochastic spill modelling of worst case credible topsides diesel loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulations were an instantaneous release based on the assumptions in Section 5.4. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volume for a topsides loss of containment..

Hydrocarbon Characteristics

Marine Diesel

Refer to Section 5.4 for a general discussion of hydrocarbon characteristics; additional information on marine diesel is provided below.

Marine diesel is a mixture of volatile and persistent hydrocarbons with low proportions of highly volatile and residual components. In general, about 6% of the oil mass should evaporate within the first 12 hours (BP <180°C); a further 35% should evaporate within the first 24 hours (180°C < BP <265°C); and a further 54% should evaporate over several days (265°C < BP <380°C). Approximately 5% of the oil is shown to be persistent. The aromatic content of the oil is approximately 3%.

If released in the marine environment and in contact with the atmosphere (i.e. surface spill), approximately 41% by mass of this oil is predicted to evaporate over the first couple of days depending upon the prevailing conditions, with further evaporation slowing over time. The heavier (low volatility) components of the oil tend to entrain into the upper water column due to wind-generated waves but can subsequently resurface if wind-waves abate. Therefore, the heavier components of this oil can remain entrained or on the sea surface for an extended period, with associated potential for dissolution of the soluble aromatic fraction.

The mass balance forecast for the constant-wind case for marine diesel shows that approximately 40% of the oil is predicted to evaporate within 36 hours. Under these calm conditions the majority of the remaining oil on the water surface would weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (**Figure 12-4**), where the winds are of greater strength, entrainment of marine diesel into the water column is indicated to be significant. Approximately two days after the spill, around 50% of the oil mass is forecast to have entrained and a further 45% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<2%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately >6 m/s).

Biological and photochemical degradation is predicted to contribute to the decay of the floating slicks and oil droplets in the water column at an approximate rate of around 0.50% per day, for an accumulated total of about 3-4% after seven days in each wind case. However, given the large proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay and/or evaporate over time scales of several weeks to a few months. This long weathering duration will extend the area of potential effect, requiring the break-up and dispersion of the slicks and droplets to reduce concentrations below the thresholds considered in this study.

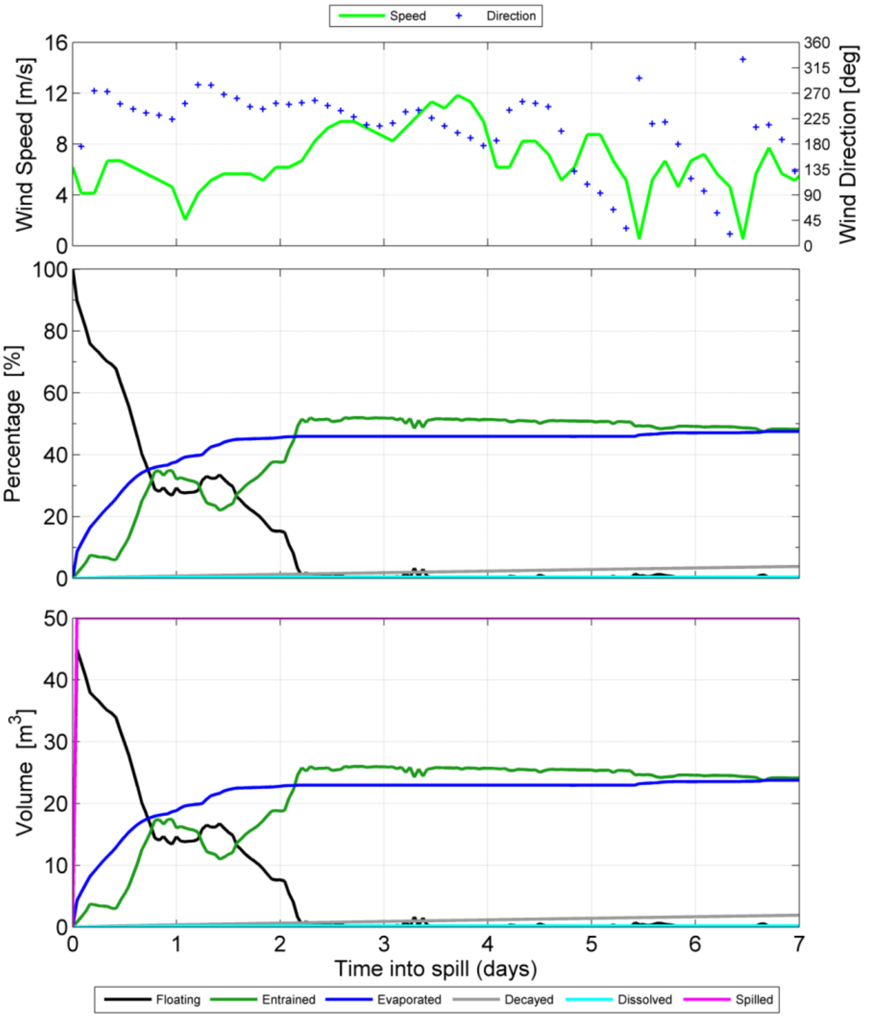

Figure 12-4: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of marine diesel spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to variable winds (top panel) at 27°C water temperature

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, infrastructure marked on marine charts), the likelihood or a topsides loss of containment has been taken as 1 (highly unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a topsides loss of containment. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (MEE-01) and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment
Potential Impacts Overview

Zone of Consequence

Surface Hydrocarbons

As described in Section 5.4, the ZoC depicted in these figures are a summary of all the locations where environmental thresholds could be exceeded for stochastic modelled scenarios.

The stochastic modelled floating hydrocarbon ZoC from the topsides diesel loss of containment scenario is forecast to drift primarily to the south-west, reflecting the competing influence of both surface currents and winds across the wide area in which a slick could travel. Modelling did not indicate contact with any sensitive receptors; therefore, no tabular summary of contact with sensitive receptors is provided for the topsides loss of containment scenario.

Entrained Hydrocarbons

Stochastic modelling results indicated entrained hydrocarbons above impact thresholds are likely to drift south-west from the release location, covering a smaller area that the surface ZoC. Stochastic modelling did not indicate contact with any sensitive receptors; therefore, no tabular summary of contact with sensitive receptors is provided for the topsides diesel loss of containment scenario.

Dissolved Hydrocarbons

The stochastic hydrocarbon spill modelling results did not indicate dissolved hydrocarbon concentrations above impact thresholds at sensitive receptors would occur.

Accumulated Hydrocarbons

Stochastic modelling results indicated no accumulation above impact thresholds from the topsides diesel loss of containment scenario was predicted to occur along any shorelines.

Consequence Assessment Summary

The credible worst-case hydrocarbon spill scenario that may arise from MEE-03 may impact upon environmental receptors; refer to MEE-04 for an assessment of a surface release of crude oil (consistent with a topsides process release). The credible crude oil volume from a topsides loss of containment (MEE-03) is smaller than the scenario presented in MEE-04; as such the potential to impact upon sensitive receptors may be lower. Receptors potentially impacted by crude oil from MEE-03 are expected to be a subset of those identified in MEE-04. The nature of the hydrocarbon is considered to be the same, as is the potential nature of contact (e.g. weathering, time to contact, contact concentration).

A topsides non-process release of marine diesel is expected to result in the potential for surface and entrained hydrocarbons above impact thresholds. Floating and entrained hydrocarbons may extend into the multiple use zone of the Gascoyne Commonwealth Marine Park. The ZoC for the diesel loss of containment overlaps the Continental Slope Demersal Fish Communities and Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KFEs. Given the nature of the release and the water depth overlapping these KEFs, no impacts to the environmental values of the KEFs will occur. There is the potential for impacts to socio-economic receptors, such as oil and gas facilities (e.g. decreased water quality affecting water intakes such as cooling) and fisheries (displacement of fishing effort). These potential impacts are considered to be isolated and of no lasting effect. Marine fauna within the ZoC may be impacted, particularly fauna associated with surface waters such as seabirds. Given the non-persistent nature of diesel and the relatively small ZoC, no population-scale impacts are expected.

On this basis, the consequence ratings for topsides process and non-process loss of containment to the atmosphere and marine environment are considered to be C and D, respectively.

Summary of Control Measures

- Maintain topsides hydrocarbon-containing infrastructure integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P01 - Pressure Vessels
    - P02 - Heat Exchangers
    - P03 - Rotating Equipment
    - P04 - Tanks
    - P08 - Piping Systems
    - P28 – Sand Management
    - F06 – ESD System
    - F21 – Relief System
- Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed with the following SCE technical performance standards:
    - E04 - Safety Critical Communication Systems
- Maintain Fire and Gas Detection and Alarm Systems on NY facility to facilitate prevention and response to

fire or gas hazards. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:

  - F01- Fire and Gas Detection and Alarm Systems.

- Maintain Safety Instrumented Systems (e.g ESD and safety instrumented functions) system, Blowdown and Open Hazardous Drains system to isolate, remove and control hazardous inventories so as to mitigate the effects of a MEE/ prevent escalation to a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F05 – ESD Valves
  - F06 – ESD System
  - F09 – Depressurisation.
- Maintain hazardous and non-hazardous open drains to remove and control environmentall hazardous liquid discharges to prevent or mitigate an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F22 – Hazardous Open Drains
  - F23 – Non-Hazardous Open Drains.
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E05 - Environmental Incident Response Equipment.
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility.
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Offloading Equipment Loss of Containment (MEE-04)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release from NY FPSO offloading equipment to the marine environment and atmosphere.		X	X		X	X	X	B	B	1	M	LCS GP PJ RB A CV SV	Acceptable if ALARP

Description of Source of Risk

Background

Crude oil is routinely transferred from the NY FPSO to offtake tankers. The offloading of crude product takes place using steam-driven pumps via cargo piping leading to a 200 m long, 400 mm diameter floating hose located at the stern of the NY FPSO.

The offtake tanker is moored to the stern of the NY FPSO in a tandem configuration via a stern mounted mooring hawser. A tug is used to provide a static tow to the offtake tanker during the offloading operation. The maximum pumping rate during normal offloading operations is 5500 m^3 per hour and the volume of the offloading hose/system is approximately 51 m^3 (hose inventory 25.9 m^3, piping system from cargo tanks inventory 25 m^3).

The following hazards could lead to loss of containment from the FSPO offloading system:

- internal corrosion;
- external corrosion;
- overpressure;
- equipment fatigue/failure;
- loss of control of offtake vessel; and
- mooring failure (during offtake operations).

Escalation from other MEEs can cause Flowline and Riser Loss of Containment:

- loss of structural integrity (MEE-06);
- loss of marine vessel separation (MEE-07); and
- loss of control of suspended load from facility lifting operations (MEE-08).

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure sections below.

Offloading Equipment Loss of Containment – Credible Scenarios

The worst case credible scenario for an offloading loss of containment modelled is considered to be approximately 1000 m^3 of NY blend crude oil, which includes the loss of the entire inventory of the offtake hose and the release associated with continued pumping at the maximum rate of 5500 m^3 oil per hour for 10 minutes. This scenario assumes the 24-hour watch would not immediately identify the incident, and instead assumes a worst case credible time of 10 minutes for detection and then activation/actuation of shutdown systems. The characteristics of the offloading equipment loss of containment scenario are summarised in **Table 12-21**.

Table 12-21: Summary of the worst-case offloading equipment loss of containment release scenario

Scenario	Hydrocarbon	Duration (minutes)	Depth (m)	Latitude (D°M'S'')	Longitude (D°M'S'')	Total Hydrocarbon Release Volume (m^3)
Offloading equipment loss of containment	NY topsides blend crude	10 minutes	Surface	21° 26' 02.661" S	114° 04' 01.325" E	1000

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO design, construction and operation. In the company's 60-year history, it has not experienced any offloading loss of containment events that have resulted in significant environmental impacts.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons from an offloading equipment loss of containment is considered an MEE (MEE-04). The hazard associated with this MEE is hydrocarbons contained within the offloading equipment.

Quantitative Spill Risk Assessment

Stochastic spill modelling of worst case credible offloading equipment loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulation was 10 minutes release based on the assumptions in **Section 5** Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volume for an offloading equipment loss of containment.

Hydrocarbon Characteristics

<u>NY Crude</u>

Refer to Section 5.4 for a general discussion of hydrocarbon characteristics.

NY topsides blend crude contains a relatively high proportion (~31% by mass) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment.

The unweathered mixture has a high dynamic viscosity (96.7 cP). The pour point of the whole oil (<-27°C) ensures it will remain in a liquid state over the annual temperature range observed on the NWS.

The mixture is composed of hydrocarbons that have a wide range of boiling points and volatilities at atmospheric temperatures, and which begin to evaporate at different rates on exposure to the atmosphere. Evaporation rates will increase with temperature, but in general about 3.3% of the oil mass should evaporate within the first 12 hours (BP <180°C); a further 14.8% should evaporate within the first 24 hours (180°C < BP <265°C); and a further 51.1% should evaporate over several days (265°C < BP <380°C).

Selective evaporation of the lower boiling-point components will lead to a shift in the physical properties of the remaining mixture, including an increase in the viscosity and pour point. This may result in solidification and/or sinking of the weathered hydrocarbon over time.

The whole oil has low asphaltene content (<0.2%), indicating a low propensity for the mixture to take up water to form water-in-oil emulsion over the weathering cycle.

Soluble aromatic hydrocarbons contribute approximately 15% by mass of the whole oil, with a large proportion (12.3%) in the C16-C20 range of hydrocarbons. These compounds will evaporate slowly, leaving the potential for dissolution of a proportion of them into the water.

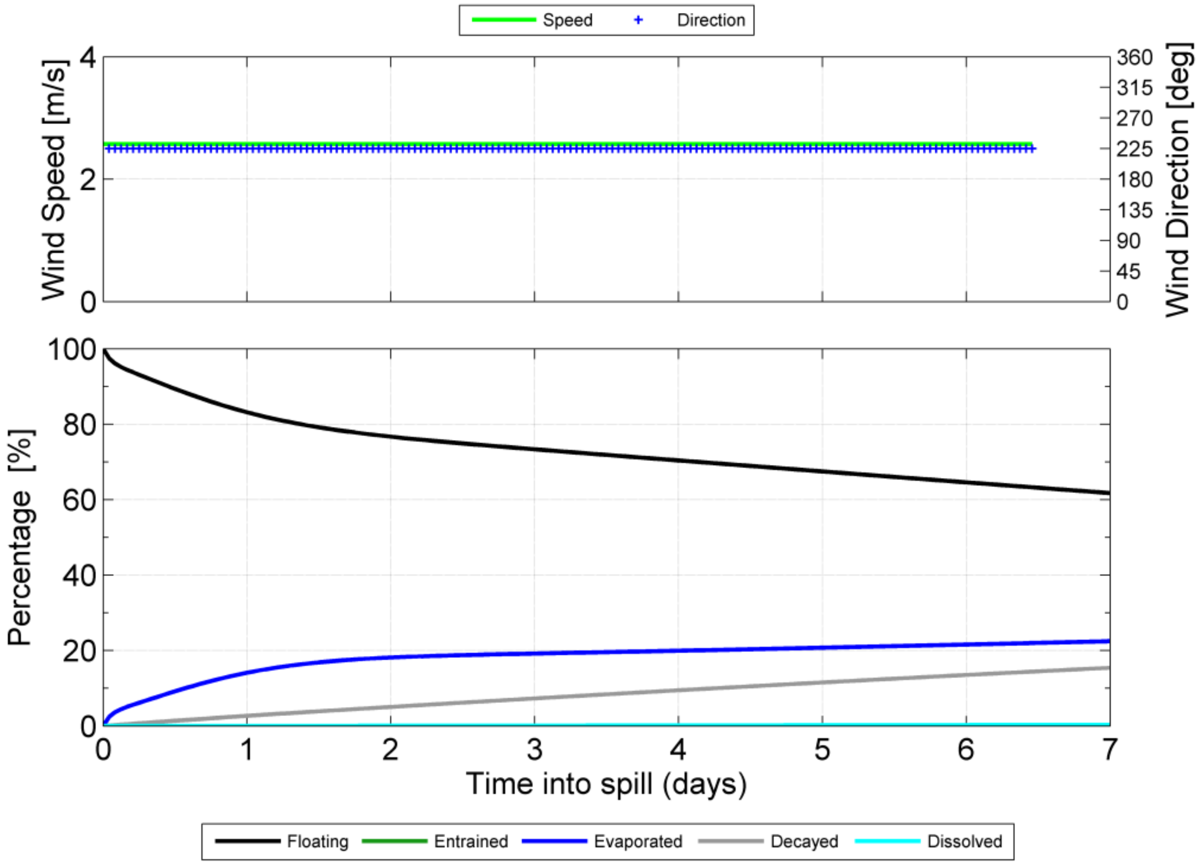

Figure 12-5: Proportional mass balance plot representing the weathering of NY topsides blend crude spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to a constant 5 kn (2.6 m/s) wind at 27°C water temperature and 25°C air temperature.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as 1 (highly unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon was considered during the impact assessment for an offloading equipment loss of containment. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts Overview

Zone of Consequence

Surface Hydrocarbons

As described in Section 5.4, the ZoC is a summary of all the locations where environmental thresholds could be exceeded for modelled scenarios.

Stochastic modelling indicated floating hydrocarbons from the offloading equipment loss of containment scenario are forecast to drift in all directions, reflecting the competing influence of both surface currents and winds across the wide area in which a slick could travel. At the surface threshold of 10 g/m2, floating oil is forecast to potentially occur up to approximately 910 km from the release site. Contact above impact thresholds was forecast along the Ningaloo Coast (**Table 12-22**).

Entrained Hydrocarbons

Entrained hydrocarbons above impact thresholds are likely to drift in all directions from the release location, which is consistent with entrainment of a surface release being influenced by surface currents. Stochastic modelling results indicated entrained hydrocarbon concentrations above impact thresholds may occur up to 250 km from the release location. No entrained hydrocarbon contact above impact thresholds with sensitive receptors was predicted (**Table 12-22**).

Dissolved Hydrocarbons

In the event of an offloading equipment loss of containment scenario occurring, a plume of dissolved hydrocarbons would potentially extend in all direction, primarily along a north-east – south-west axis. Stochastic modelling results indicated dissolved hydrocarbon concentrations above impact thresholds may occur up to 60 km from the release location. No dissolved hydrocarbon contact above impact thresholds with sensitive receptors was predicted (**Table 12-22**).

Accumulated Hydrocarbons

The stochastic hydrocarbon spill modelling indicated the potential for shoreline accumulation above impact thresholds. There is a potential for accumulation of oil on shorelines, with a maximum accumulated volume of 330 m^3 forecast at Ningaloo Coast Middle WHA and a maximum local accumulated concentration on shorelines of 6.1 kg/m^2 forecast at Ningaloo Coast Middle WHA (**Table 12-22**).

Table 12-22: Key receptor locations and sensitivities potentially contacted above impact thresholds by the offloading equipment loss of containment scenario with summary hydrocarbon spill contact

Environmental setting	Location/name	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 deep water 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 inter-nesting 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)
		Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure)																													Hydrocarbon contact and fate			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities/Habitats								Protected Species									Other Species										
Offshore[9]	Commonwealth waters	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	
	Gascoyne CMP	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓					✓
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓					✓
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			✓

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

Summary of Potential Impacts to environmental values(s)

Consequence Assessment Summary

The credible worst-case hydrocarbon spill scenario that may arise from MEE-4 are impacts upon the Ningaloo Coast, Muiron Islands and Montebello Islands; refer to **Table 12-22** for a summary of receptors identified by the stochastic spill modelling studies. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01.

The credible worst-case hydrocarbon volumes that can credibly be released by MEE-04 are significantly smaller than the credible worst-case loss of well containment volumes considered in MEE-01. Additionally, the credible release durations are significantly shorter.

Summary of Control Measures

- Maintain offloading equipment hydrocarbon-containing infrastructure integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P08 – Piping Systems
  - P22 – Bilge, Ballast and Cargo System
  - P23 – Mooring Systems
  - F06 – ESD System
  - F21 – Relief System.
- Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed with the following SCE technical performance standard:
  - E04 - Safety Critical Communication Systems.
- Maintain Fire and Gas Detection and Alarm Systems on NY facility to facilitate prevention and response to fire or gas hazards. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F01- Fire and Gas Detection and Alarm Systems.
- Maintain Safety Instrumented System (Safety Instrumented Functions and ESD actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition (e.g through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F06 – ESD System
  - F05 – Valves.
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E05 - Environmental Incident Response Equipment.
- Maintain stability and reduce hull stresses during offloading to prevent or mitigate an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P22 – Bilge, Ballast and Cargo System
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: FPSO Cargo Tank Loss of Containment (MEE-05)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release caused by a cargo tank loss of containment.		X	X	X	X	X	X	B	A	1	H	LC S GP PJ RB A CV SV	Acceptable if ALARP

Description of Source of Risk

Background

The NY FPSO maintains a total useable cargo tank storage volume of at least 1,200,000 barrels (excluding slops tank space), which is distributed among 14 cargo tanks. A loss of containment from a cargo tank may result in a significant volume of hydrocarbons (NY topsides blend crude) being released to the marine environment. Due to the potential consequences, a cargo tank loss of containment is considered an MEE (MEE-05). The potential hazard sources that could instigate a cargo tank loss of containment are:

- corrosion;
- overpressure or underpressure;
- tank leakage/over filling;
- equipment fatigue;
- loss of containment between cargo tanks
- loss of cargo tank atmosphere control; and
- cargo tank vacuum.

Escalation from other MEEs can cause NY FPSO cargo tank loss of containment includes:

- loss of structural integrity (MEE-06);
- loss of marine vessel separation (MEE-07) ; and
- loss of control of suspended load from facility lifting operations (MEE-08).

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure sections below.

FPSO Cargo Tank Loss of Containment – Credible Scenarios

A cargo tank loss of containment could result in a release of between 14,679 m^3 and 31,462 m^3 of stabilised NY topsides blend crude if a single cargo tank lost its entire inventory when full. However, Woodside has determined there is a credible loss of containment scenario caused by bulkhead damage resulting in the loss of two adjacent cargo tanks during off-take operations. As such, the worst case credible loss of containment scenario from a cargo tank spill on NY is taken as 40,828 m^3 of NY topsides blend crude. This volume is based on the complete release of the maximum volumes of the two largest port or starboard wing tanks. The cargo tank loss of containment scenario assumes the initial release of half of the maximum credible spill volume within 20 minutes, with the remaining hydrocarbons released over the following 16 hours. A loss of containment of diesel fuel stored within the vessel hull due to vessel collision is also a credible event. The single largest inventory of diesel within the hull is the Port Inner Diesel Oil Bunker Tank (1683.3 m^3). The cargo tank loss of containment event has been selected to inform the risk assessment due to the larger potential release volume. Release characteristics for cargo tank loss of containment scenario are summarised in (Table 12-23).

Table 12-23: Summary of worst-case cargo tank loss of containment scenario

Scenario	Hydrocarbon	Duration (hours)	Depth (m)	Latitude (D°M'S'')	Longitude (D°M'S'')	Total Hydrocarbon Release Volume (m^3)
FPSO cargo tank loss of containment	NY topsides blend crude	20,414 in first 20 minutes, remainder over 16 hrs	Surface	21° 26' 02.661" S	114° 04' 01.325" E	40,828

Loss of Structural Integrity – Credible Scenarios

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO design, construction and operation. In the company's 60-year history, it has not experienced any cargo tank integrity events that have resulted in significant releases or significant environmental impacts. The NY facility has never experienced a worst-case cargo tank loss of containment in its operational history.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons from an NY FPSO cargo tank loss of containment is considered an MEE (MEE-05). The hazard associated with this MEE is hydrocarbons within the NY FPSO cargo tanks.

Quantitative Spill Risk Assessment

Stochastic spill modelling of the maximum credible spill for NY FPSO cargo tank loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulation was a phased release (20,414 m^3 over 20 minutes, with 20,414 m^3 released over the following 16 hours). Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the ZoC and the potential impacts from the identified worst-case credible release volume for an NY FPSO cargo tank loss of containment.

Hydrocarbon Characteristics

NY topsides blend crude was selected as the hydrocarbon type for the release scenario. It is considered to be representative of the hydrocarbons that may credibly be stored within the NY FPSO cargo tanks. Refer to MEE-04 for the characteristics of NY topsides blend crude.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as 1 (highly unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a maximum credible spill scenario from NY FPSO cargo tank loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Potential Impacts Overview

Zone of Consequence

Surface Hydrocarbons

As described previously the ZoC is a summary of all the locations where environmental thresholds could be exceeded for modelled scenarios.

The stochastic modelling results indicated floating hydrocarbons from the NY FPSO cargo tank loss of containment scenario are forecast to drift in all directions, reflecting the competing influence of both surface currents and winds across the wide area in which a slick could travel. At the surface threshold of 10 g/m^2, floating oil is forecast to potentially occur up to approximately 980 km from the release site. Potential contact above impact thresholds was forecast at a range of receptors (**Table 12-24**).

Entrained Hydrocarbons

Entrained hydrocarbons above impact thresholds are likely to drift in all directions from the release location, with an entrained plume extending a considerable distance to the south. Stochastic modelling results indicated entrained hydrocarbon concentrations above impact thresholds may occur up to 1000 km from the release location. Potential contact above impact thresholds was forecast at a range of receptors (**Table 12-24**).

Dissolved Hydrocarbons

In the event of an offloading equipment loss of containment scenario occurring, a plume of dissolved hydrocarbons would potentially extend in all directions, with a plume most likely to extend south from the release location. Dissolved hydrocarbon concentrations above impact thresholds may occur up to 715 km from the release location. Potential contact above impact thresholds was forecast at a range of receptors (**Table 12-24**).

Accumulated Hydrocarbons

The stochastic hydrocarbon spill modelling results indicated the potential for shoreline accumulation above impact thresholds was high. Modelling indicated a maximum local accumulation of 23.1 kg/m^2 on the Ningaloo Coast South WHA. Potential accumulation above impact thresholds was forecast at a range of receptors (**Table 12-24**).

Table 12-24: Key receptor locations and sensitivities potentially contacted above impact thresholds by the FPSO cargo tank loss of containment scenario with summary hydrocarbon spill contact

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			
		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 deep water 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 inter-nesting 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[10]	Commonwealth waters	✓	✓					✓		✓					✓	✓				✓	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	
	Argo-Rowley Terrace CMP	✓						✓							✓	✓			✓			✓	✓	✓		✓			✓		✓			
	Abrolhos CMP	✓	✓					✓							✓	✓		✓		✓		✓	✓	✓	✓	✓			✓			✓	✓	
	Carnarvon Canyon CMP	✓	✓					✓		✓														✓	✓	✓			✓		✓	✓		
	Gascoyne CMP	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	
	Montebello CMP	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	
	Shark Bay Open Ocean (including CMP)	✓	✓					✓							✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	
Oceanic Reefs and	Mermaid Reef and CMP	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓		✓			
	Clerke Reef and State Marine Park	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓		✓			✓
	Imperieuse Reef and State Marine Park	✓	✓	✓			✓	✓		✓						✓			✓	✓		✓	✓	✓	✓			✓	✓		✓			✓
Shoals and	Rankin Bank	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			✓			

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

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			
		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 deep water 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 inter-nesting 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)
	Glomar Shoals	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			✓			
	Rowley Shoals (including Sate Maine Park)	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			✓			✓
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			✓
	Lowendal Islands (including State Nature Reserve)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			✓
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓					✓
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					✓
	Pilbara Islands – Middle Group	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					✓
	Pilbara Islands –	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					✓

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			
		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 deep water 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 inter-nesting 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)
	Northern Island Group (Sandy Island Passage Islands – State nature reserves)																																	
	Bernier and Dorre Islands	✓	✓	✓	✓		✓	✓			✓	✓		✓		✓			✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Mainland (nearshore waters)	Southern Pilbara Shoreline	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓						✓
	Middle Pilbara Shoreline	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓						✓
	Northern Pilbara Shoreline	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓						✓
	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
	Dampier Archipelago	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					✓
	Eighty Mile Beach		✓		✓	✓	✓					✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓					✓
	Shark Bay – WHA and Marine Park	✓	✓	✓	✓	✓	✓					✓		✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

Summary of Potential Impacts to environmental values(s)

Consequence Assessment Summary

The credible worst-case hydrocarbon spill scenario that may arise from MEE-05 may impact upon a number of environmental receptors; refer to **Table 12-24** for a summary of receptors identified by the stochastic spill modelling studies. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01; for a description of potential impacts.

The credible worst-case hydrocarbon volumes that can credibly be released by MEE-05 are considerably smaller than the credible worst-case loss of well containment volumes considered in MEE-01. Additionally, the credible release durations are significantly shorter.

Summary of Control Measures

- Maintain offloading equipment hydrocarbon-containing infrastructure integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P08 – Piping Systems
    - P21 – Substructure
    - P22 – Bilge, Ballast and Cargo System
    - P25 – Purge Gas and Blanketing System
    - F06 – ESD System
    - F21 – Relief System
- Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies. Integrity will be managed with the following SCE technical performance standards:
    - E04 - Safety Critical Communication Systems.
- Maintain Fire and Gas Detection and Alarm Systems on NY facility to facilitate prevention and response to fire or gas hazards. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F01- Fire and Gas Detection and Alarm Systems.
- Maintain bilge detection and alarm systems to mitigate an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P22 – Bilge, Ballast and Cargo System.
- Maintain Safety Instrumented System (Safety Instrumented Functions and ESD actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition (e.g through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F06 – ESD System
    - F05 – Valves.
- Maintain hazardous open drains to remove and control environmentally hazardous liquid discharges to prevent or mitigate an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P22 – Bilge, Ballast and Cargo System
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - F22 – Open Hazardous Drains;
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Loss of Structural Integrity (MEE-06)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release caused by a loss of structural integrity, leading to: • MEE-02 – Subsea flowline and riser loss of containment; • MEE-03 – Topsides loss of containment; • MEE-04 – Offloading equipment loss of containment; or • MEE-05 – FPSO Cargo tank loss of containment.		X	X		X	X	X	B	A	1	H	LC S GP PJ RB A CV SV	Acceptable if ALARP

Description of Source of Risk

Background

The NY FPSO contains hydrocarbons in a range of infrastructure, including cargo tanks, process inventory, non-process inventory, flowlines and risers.

Woodside has identified the potential for hydrocarbon release due to the extreme environmental conditions or other causes which result in an exceedance of the design criteria and a catastrophic failure of the facility and individual equipment (e.g. cranes, flare, etc.) which could cause damage to adjacent equipment, leading to hydrocarbon releases to the environment.

Extreme environmental conditions (cyclone) could result in loss of structural integrity of the NY FPSO resulting in significant oil spill to the environment (from risers, cargo tanks and/or topsides equipment).

There is also the possibility of NY FPSO capsize or foundering caused by strong winds and extreme waves. This may induce pipework fatigue and loose/dislodged objects/projectiles causing impact to equipment/pipework resulting in loss of containment. Structural failures could be localised, or could, in more extreme situations, result in loss of containment from multiple storage locations on the NY FPSO.

Extreme environmental conditions may also result in movement of the vessel and result in releases from flowlines/risers (MEE-02) or topsides equipment or storage (MEE-02–MEE-05). The worst case environmental consequence ranking is a ‘A’ for these events related to Loss of Structural Integrity.

The release of hydrocarbons as a result of loss of structural integrity is considered a Major Environment Event (MEE 06). The hazard associated with this MEE is hydrocarbons in the NY facility.

The following hazards could lead to loss of containment from the NY FPSO topsides:

- internal and external corrosion;
- equipment fatigue;
- extreme weather;
- mooring system failure;
- vessel stresses through loading and stability; and
- fire or explosion escalation to structure (including events captured in MEE-02–MEE-05).

A number of common failure causes due to human error and SCE failures are presented in the generic Human Error and SCE failure sections below.

Loss of Structural Integrity – Credible Scenarios

A loss of structural integrity could result in a significant release of hydrocarbons. A loss of structural integrity may result in credible spill scenarios consistent with a loss of well containment (MEE-01), subsea flowline and riser loss of containment (MEE-02), topsides loss of containment (MEE-03) and NY FPSO cargo tank loss of containment (MEE-05). The worst case credible spill scenarios associated with these MEEs are discussed in the relevant sections above; refer to these sections for further information.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO design, construction and operation. In the company's 60-year history, it has not experienced any loss of structural integrity events that have resulted in significant releases or significant environmental impacts. The NY facility has never experienced a worst-case loss of containment in its operational history.

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons from a loss of structural integrity is considered an MEE (MEE-06). The hazard associated with this MEE is hydrocarbons contained within the NY FPSO and associated infrastructure.

Quantitative Spill Risk Assessment

Credible worst case stochastic spill modelling for the scenarios associated with MEE-01, MEE-02, MEE-03 and MEE-05 has been undertaken. Results of these modelling studies have been used to inform the consequence assessment for these MEEs; these assessments are applicable to the consequence assessment for a loss of structural integrity event..

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as 1 (highly unlikely).:

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a loss of structural integrity. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure..

Summary of Control Measures

- Maintain structural integrity to ensure availability of critical systems during a major accident or environment event, and prevent structural failures from contributing to escalation of a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P07 – Topsides / Surface Structures
  - P21 – Substructures
  - P22 – Blige, Ballast and Cargo System Integrity
  - P23 – Mooring Systems
  - P24 – Propulsion and Steering Systems
  - P33 – Equipment Supporting Marine Navigation
- Maintain control of ignition sources and fire protection to prevent loss of structural integrity. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F14 – Deluge System
  - F15 – Manual Fire Fighting Equipment
  - F16 – Foam System
  - F17 – Fire Water Pump
  - F18 – Fire Water Main
  - F19 – Gaseous Extinguishing System

- F20 – Passive Fire and Explosion Protection
- F27 – Control of Ignition Sources

- Maintain availability of critical external and internal communication systems to facilitate response to accidents and emergencies. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E04 – Safety Critical Communication Systems
- Maintain vessel stability and structural integrity to prevent structural failures from contributing to escalation of an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P21 – Substructure
  - P22 – Blige, Ballast and Cargo System
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E05 - Environmental Incident Response Equipment, including;
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Loss of Marine Vessel Separation (MEE-07)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon release from flowline and riser to the marine environment and atmosphere		X	X	X	X	X	X	B	B	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Hydrocarbon release from topsides equipment, offloading equipment or cargo tanks to the marine environment and atmosphere		X	X	X	X	X	X	B	A	1	H		

Description of Source of Risk

A loss of marine vessel separation between a vessel and the NY facility may result in a loss of hydrocarbon containment from the NY facility and / or the release of fuel from the vessel. A vessel collision with the NY facility has been identified as a potential MEE (MEE-05). Vessel collisions can arise from:

- Visiting vessel collisions associated with support vessels and offloading tankers – ships which are visiting can accidentally collide with the NY FPSO during approach to, or while manoeuvring or stationed alongside, the FPSO; and
- Errant passing vessel collision – ships which are not visiting the NY FPSO (i.e. passing vessels) can, for one reason or another, move off-course and collide with the FPSO.

The different collision hazards involve significantly different sized vessels and collision speeds, hence, differing impact energies and consequences, and have been assessed.

Visiting Vessels

Visiting vessels are defined as those which are routinely used to service, or offtake cargo from, the NY FPSO. Operating procedures will dictate how vessels are operated, loaded and unloaded, but it will generally occur so that the prevailing winds move the vessel away from the facility. The primary causes of visiting vessel collisions are failure to follow safe procedures and communication errors between the marine vessels and facility operations. These errors could be worsened by station keeping failures or operations in adverse weather conditions;

The following design features and procedures are in place to reduce the likelihood of a major collision or mitigate the consequences from a visiting vessel impact:

- facility marine operating procedures;
- marine assurance activities;
- supply or standby vessel contractor selection and management;
- third party maintenance and inspection;
- third party position keeping equipment; and
- weather monitoring.

Errant Passing Vessels

Errant passing vessels are defined as third party vessels that enter the facility 500 m Petroleum Safety Zone, but do not call at installations (i.e. not supply or standby vessels). The collision can be powered or drifting. Either has the potential to cause significant damage to the NY FPSO. The causes of errant passing vessel collisions include: failure of propulsion or steering systems; adverse weather conditions resulting in poor visibility or rough seas or human error.

Woodside implements the following controls to help prevent passing vessels entering the NY FPSO 500 m Petroleum Safety Zone:

- facility marked on Marine Charts;
- collision warning system;
- visual navigation aids (NAVAIDS) as well as flares and lighting to make the facility highly visible to approaching vessels;
- marine radio package (critical communications); and
- facility marine procedures.

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure sections below.

Loss of Marine Vessel Separation – Credible Scenarios

A loss of marine vessel separation could result in a significant release of hydrocarbons. Hydrocarbon releases will result in a spill to the marine environment as described in MEE-02 – subsea flowline and riser loss of containment, MEE-03 – Topsides loss of containment, MEE-04 – Offloading equipment loss of containment and MEE-05 – FPSO cargo tank loss of containment. Worst case hydrocarbon release scenarios that could result from loss of marine vessel separation are discussed in the relevant sections referenced above. Relevant trajectory modelling, as applicable to these scenarios, is also discussed in the relevant sections. In addition, vessel cargo, including marine diesel inventory, could be spilled if the cause of the loss of facility integrity was a collision from a support vessel.

A loss of vessel separation may lead to the accidental release of marine diesel from the fuel tanks on the vessel(s) involved. 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; and
- 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 Operational Area, vessel grounding in relation to the Petroleum Activities Program is not considered a credible risk.

A collision between the NY FPSO or subsea support vessel with a third-party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels) was considered the only credible event that could release a significant quantity of marine diesel to the environment. This was assessed as being credible but highly unlikely given:

- the facility support vessels typically operate close to the NY FPSO (an area avoided by commercial shipping and fishing);
- the presence of subsea vessels in the Operational Area is typically temporary (e.g. while undertaking IMR activities);
- vessels undertaking the Petroleum Activities Program typically operate of low speeds or are stationary; and
- the standard vessel operations and equipment in place to prevent collision at sea, and the construction and placement of storage tanks.

The largest tank of a facility support or subsea support vessel is unlikely to exceed 105 m^3. As such, the worst-case credible spill of marine diesel from a vessel is considered to be an instantaneous loss of the contents of a 105 m^3 tank.

The marine diesel component of the topsides loss of containment MEE described in **MEE-01** is considered a suitable surrogate for the risk assessment of a 105 m^3 release of marine diesel from a vessel for the following reasons:

- the volume is considerably larger, making the assessment inherently conservative;
- the release location (the NY FPSO) is the area where vessels undertaking the Petroleum Activities Program most commonly occur; and
- the hydrocarbon type (marine diesel) is consistent with fuel used by vessels undertaking the Petroleum Activities Program.

Refer to **MEE-01** for a description of the surrogate marine diesel release scenario and environmental risk assessment.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO design, construction and operation. In the company’s 60-year history, it has not experienced any loss of vessel separation events that have resulted in significant releases or significant environmental impacts. The NY facility has never experienced a worst-case hydrocarbon release from a loss of vessel separation in its operational history.

Decision Type

A decision type ‘B’ has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company values and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

A loss of marine vessel separation is considered an MEE (MEE-07). The hazard associated with this MEE is the hydrocarbon inventory of the NY FPSO, subsea flowlines and riser, and fuel onboard vessels.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon scenarios for MEE-02, MEE-03, MEE-04 and MEE-05 are considered to apply to a loss of marine vessel separation, as they may credibly arise from damage to the NY facility and loss of vessel fuel.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, infrastructure marked on marine charts), the likelihood has been taken as 1 (Highly Unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a loss of vessel separation. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill and relevant literature and studies considering the effects of hydrocarbon exposure.

Summary of Control Measures

- Maintain collision warning systems and navigational aids to alert facility of a potential collision with marine vessels, and to alert marine vessels of facility location so that they may take timely action to avoid the facility and hence reduce likelihood of collision. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P33 – Collision Prevention Systems
  - P34 Collision Prevention Systems
  - E04 – Safety Critical Communications Systems
- Maintain hull structural integrity to prevent structural failures as a result of ship collision from contributing to escalation of an MEE. Integrity will be managed with the following SCE technical performance standards
  - P21 - Substructure
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E05 - Environmental Incident Response Equipment, including;
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Loss of Control of Suspended Load (MEE-08)

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	Risk Rating	ALARP Tools	Acceptability
Hydrocarbon Release from Flowline and Riser to the Marine Environment and Atmosphere.		X	X		X	X	X	B	B	1	M	LCS GP PJ RBA CV	Acceptable if ALARP
Hydrocarbon Release from Topsides Equipment to the Marine Environment and Atmosphere.		X	X		X	X	X	B	C	1	M		

Description of Source of Risk

Lifting activities on the NY FPSO can take place from several cranes located on the FPSO. Lifts may occur between supply vessels and laydown areas, or between laydown areas. Lifting operations performed using the NY FPSO or visiting vessel cranes could potentially lead to dropped objects impacting assets (topsides equipment, subsea infrastructure) inside the NY FPSO 500 m Petroleum Safety Zone. This may lead to a hydrocarbon loss of containment from topsides or subsea infrastructure. Loss of suspended load has been identified as an MEE (MEE-08). A loss of suspended load may arise from:

- lifting equipment failure; or
- facility lifting operations.

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure sections below..

Loss of Suspended Load – Credible Hydrocarbon Spill Scenario

The potential outcome of a loss of control of a suspended load is a topsides and/or subsea flowlines and risers loss of containment. Refer to **MEE-02** and **MEE-03** for a description of subsea and topsides loss of containments scenarios, respectively.

Decision Type, Risk Analysis and ALARP Tools

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

Decision Type

A decision type 'B' has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications, should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology and hydrocarbon spill trajectory modelling. Company values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation. A loss of control of a suspended load is considered an MEE (MEE-08). The hazard associated with this MEE is the hydrocarbon inventory of subsea flowlines and risers, or topsides process and non-process hydrocarbons.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon scenarios for MEE-02 and MEE-03 are considered to apply to a loss of control of suspended load, as they may credibly arise from damage to hydrocarbon containing subsea infrastructure within the 500 m Petroleum Safety Zone and NY FPSO topsides infrastructure. Refer to **MEE-02** and **MEE-03** for additional information on quantitative spill risk assessments for these scenarios.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as 1 (highly unlikely).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbons were considered during the impact assessment for a loss of vessel separation. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (**MEE-01**) and relevant literature and studies considering the effects of hydrocarbon exposure.

Summary of Control Measures

- Maintain integrity of FPSO lifting equipment to prevent lifting equipment failure or dropped / swinging loads that could result in an MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P15 - Cranes
    - P20 – Lifting Equipment.
- Maintain structural integrity (impact protection) to ensure availability of critical systems during a major accident or environment event, and prevent structural failures from contributing to escalation of a MEE. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - P21 – Substructures.
- Maintain environmental incident response equipment to enact the NY First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
    - E05 – Environmental Incident Response Equipment.
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility.
- Incident reorts are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

MEE Common Cause Event failure mechanisms: SCE Failure and Human Error

This section presents common mode failure causes and controls applicable across MEEs which are also observed within the bowties of the MEEs discussed within sections above. Controls, EPSs and MCs presented within this section are also considered relevant to MEE-01 to MEE-08.

NY: Major Environmental Event Datasheet	
MEE Number	ALL
Hazard Description	Generic Safety Critical Equipment failure (CCE-01)
Hazard Ref ID	N/A
HAZARD DESCRIPTION	
Hazard Overview and Scope	
There are a number of causes which contribute to failures of SCEs and other systems which might protect against a MEE. These include: • Maintenance errors; • Defects; • Electrical supply failure; • Hydraulic supply failure; and • Adverse environmental conditions.	

Summary of Control Measures

- Maintain hydraulic supplies (e.g to support Safety Instrumented Systems and actuation of SCE valves/isolations). Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F06 – ESD System
  - P10 - Wells
- Maintain protection from environmental conditions. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - P01 – Pressure Vessels
  - P02 – Heat Exchanger
  - P03 – Rotating Equipment
  - P04 - Tanks
  - P07 – Topsides / Surface Structures
  - P08 – Piping Systems
  - P09 – Pipeline Systems
  - P10 – Wells
  - P21 – Substructures.
- Maintain UPS / emergency power system to supply Essential safety systems. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - F25 – UPS / Emergency Power
- Maintain climate controlled enclosures to protect essential equipment from adverse environmental conditions. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:
  - E02 – Safety Critical Buildings
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the NY facility

NY: Major Environmental Event Datasheet	
MEE Number	ALL
Hazard Description	Generic Human Errors
Hazard Ref ID	N/A

HAZARD DESCRIPTION

Hazard Overview

There are a number of causes of human errors which contribute to MEEs, or which can result in failure or degradation of the controls in place to protect against MEEs. These are presented in the following bowtie pages and include:

- task issues, e.g. poor task design; time pressures, task complexity;
- poor physical interfaces/working environment;
- provision of inappropriate tools for the task;
- communication errors, i.e. poor-quality information, lack of clarity in instructions;
- operator failings, e.g. competence, fitness, impairment or fatigue; and
- organisational issues, e.g. peer pressure, poor safety culture, inadequate supervision, lack of clarity on roles and expectations.

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

The table below compares the adopted control measures for this oil spill response activity against the environmental values that can be affected when they are implemented.

Table 12-25: 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	
Surface Dispersant Application			X		X	X	X
Containment and Recovery			X		X	X	X
Subsea Dispersant Injection		X	X		X	X	X
Source control		X	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

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 seasnakes 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 oil 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); and
- Excessive removal of substrate causing erosion and instability of localised areas of the shoreline.

Human Presence

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.

Drill cuttings and Drilling Fluids Environmental Impact Assessment for Relief Well Drilling

The identified potential impacts associated with the discharge of drill cuttings and fluids during a relief well drilling activity include a localised reduction in water and seabed sediment quality, and potential localised changes to benthic biota (habitats and communities).

A number of direct and indirect ecological impact pathways are identified for drill cuttings and drilling fluids as follows:

- 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 physico-chemical composition of sediments, and burial and potential smothering effects to sessile benthic biota; and
- Potential contamination and toxicity effects to benthic and in-water biota from drilling fluids.

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, smothering effects from raised sedimentation concentrations as a result of elevated Total Suspended Solids (TSS), changes to the physico-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 are generally confined to within a few hundred metres of the discharge point (International Association of Oil and Gas Producers 2016) (ie within the ZoC for a hydrocarbon spill event).

The discharge of drill cuttings and unrecoverable fluids from relief well drilling is expected to increase turbidity and TSS 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. Cuttings with retained (unrecoverable) drilling fluids are discharged below the water line at the MODU location, resulting in drill cuttings and drilling fluids rapidly diluting, as they disperse and settle through the water column. The dispersion and fate of the cuttings is determined by particle size and density of the retained (unrecoverable) drilling fluids, therefore, the sediment particles will primarily settle in proximity to the well locations with potential for localised spread downstream (depending on the speed of currents throughout the water column and seabed) (IOGP 2016). The finer particles will remain in suspension and will be transported further before settling on the seabed.

These conclusions were supported by discharge modelling which was undertaken by Woodside in support of the Greater Enfield Development Environment Plan (Woodside Doc # V1000RF1400289174). Modelling results indicating that the TSS plume of suspended cuttings will typically disperse to the south-west while oscillating with the tide and diminish rapidly with increasing distance from the well locations. Maximum TSS concentrations predicted for 100 m; 250 m and 1 km distances from the wellsite were 7, 5 and 1 mg/L, respectively. Furthermore, water column concentrations below 10 mg/L remain within 235 m of the discharge location for each modelled well. For all well discharge locations (outside of direct discharge sites), TSS concentration did not exceed 10 mg/l. Nelson et al. (2016) identified <10 mg/L as a no effect or sub-lethal minimal effect concentration.

The low sensitivity of the deepwater benthic communities/habitats within and in the vicinity of relief well locations, combined with the relatively 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 indicate that any localised impact would likely be of a slight magnitude (especially when considering the broader consequence of the LOC event a relief well drilling activity would be responding too).

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 oil/water mixture), recovered from containment and recovery and shoreline cleanup operations
- Semi-solids/solids (oily solids), collected during containment and recovery and shoreline cleanup operations
- Debris (e.g. seaweed, sand, woods, plastics), collected during containment and recovery and shoreline cleanup 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 oil 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.

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.

respect of the impacts and risks assessed the following treatment measures have been adopted. It must be recognised that this environmental assessment is seeking to identify how to maintain the level of impact and risks at levels that are ALARP and of an acceptable level rather than exploring further impact and risk reduction. It is for this reason that 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

Distribution of entrained hydrocarbons

- Only apply surface dispersants within the Zone of Application and on BAOAC 4 and 5
- Continuous monitoring of dispersed oil plume and visual monitoring of effectiveness

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

Human Presence

- Shoreline access route (foot, car, vessel and helicopter) with the least environmental impact identified will be selected by a specialist in SCAT operations
- Vehicular access will be restricted on dunes, turtle nesting beaches and in mangroves.

Waste generation

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

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	Feedback	Woodside Assessment	Woodside's Response
Department of Industry, Innovation and Science	Email with fact sheet	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Mines, Industry Regulation and Safety (*formerly Department of Mines and Petroleum*)	Email with fact sheet	**Date:** 17 November 2017 **Feedback summary:** The Department acknowledged that Woodside will revise and submit an EP for the operation of the NY facility. The Department reviewed the communications provided and advised that no further information is required.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required. **Attached: Appendix F**
AMSA (maritime safety)	Email with fact sheet	**Date:** 5 December 2017 **Feedback summary:** The Authority advised that it had no comments to provide about the EP.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required. **Attached: Appendix F**
Australian Hydrographic Service	Email with fact sheet	**Date:** 7 November 2017 **Feedback summary:** The Service acknowledged receipt of Woodside's email.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required. **Attached: Appendix F**
Department of Primary Industries and Regional Development (*formerly Department of Fisheries (Western Australia)*)	Email with fact sheet and fishery map	**Date:** 28 November 2017 **Feedback summary:** The Department thanked Woodside for providing an update and stated that it considers itself a relevant person with respect to this activity. The Department noted that the advice contained in the email is current for six	Woodside acknowledged the timeframe that the Department's advice remains valid. Woodside also advised that the NY operations are ongoing under the current EP and that the EP is being revised to incorporate activities associated	**Response/Action:** No further action required. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		months from the time of the correspondence, but reserves its right to update its advice should it be required. To facilitate this, the Department expects to receive notification of the planned commencement of activities as soon as practicable and be provided with an opportunity to respond within a reasonable time frame. Once proposed activities have commenced, the advice remains current for the duration of the EP. The Department requested regular updates on the progress of the proposed activities. The Department recommended that Woodside maintain ongoing consultation with WAFIC and directly with potentially affected fisheries. The Department also expects Woodside to consult with Recfishwest and Native Title representative bodies, the Department of Aboriginal Affairs and other relevant parties where operations have potential to impact on Native title or customary fishing rights. The Department requested that specific strategies are developed in the EP or OPEP to mitigate risks/potential impacts on spawning grounds and nursery areas for key fish species in the area. The Department stated that general information is available in Fisheries Occasional Publication No. 112, but proponents are expected to seek more complete and contemporary information as appropriate. The Department also requested that baseline marine data is collected to compare against any post-spill monitoring data and that this data is made available to the Department on request. Further	with the GE Project. Woodside advised that operations EPs need to be revised at least every five years and that a commencement date is not directly applicable to this ongoing activity. Woodside confirmed the relevant stakeholders consulted for this activity. Woodside advised that it selects oil spill response strategies based on Net Environmental Benefit Analysis (NEBA). The NEBA process takes into account potential benefits/impacts of response strategies to all environmental sensitivities. Woodside advised that it has consistently had its operational and scientific monitoring programs accepted by the NOPSEMA in previous EP submissions. The operational and scientific monitoring programs for this EP are consistent with those accepted. Acceptance of prior EPs shows that Woodside's approach is consistent with NOPSEMA guidance. Woodside confirms that the NEBA process includes analysis of potential benefits/impacts of spawning grounds and nursery areas. Woodside ensures compliance	

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		guidance can be found in the Operational and Scientific Monitoring Program advice statement by NOPSEMA. The Department noted that vessel, equipment and facility operators must take reasonable measure to minimise the risk of committing offences under the *Fish Resources Management Act 1994* and associated regulations. The Department listed two ways to demonstrate commitment, including utilising the Department's biofouling risk assessment tool or actively using a biofouling management plan and record mood that meets the requirements. The Department strongly recommended management to ALARP for large offshore facilities including MODUs, CPFS and the like. The Department advised that operators should act to manage residual risk of vessels and facilities after arrival in or off WA waters. The Department recommended that a follow-up marine pest inspection or survey is conducted at least 75 days after departure for WA. Any equipment coming from overseas or interstate should be either new, or thoroughly cleaned and then dried for 24 hours and inspected for marine pests before use. The Department requested that the presence of any suspected marine pest or disease be reported within 24 hours by email or phone. This includes any organism listed in the WA Prevention List for Introduced Marine Pests and any other non-endemic organism that demonstrates	with biosecurity requirements through its implementation of its own Invasive Marine Species Management Plan, which is supported at a Commonwealth level. This process demonstrates compliance with the Fish Resources Management Act 1994. Woodside strongly encourages its contractors to use the Department's Vessel Check tool to proactively manage Invasive Marine Species risk when not on contract to the company. Woodside advised that suspected or confirmed presence of marine pest or disease will be reported to the Department within 24 hours.	

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		invasive characteristics. The Department stated the importance of forwarding information to vessel operators.		
Commonwealth fisheries - North West Slope Trawl - Western Tuna and Billfish Fishery - Western Deepwater Trawl	Email with fact sheet and fishery map	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Western Australian Fisheries - Pilbara Fish Trawl - Pilbara Trap - Marine Aquarium Fish - Specimen Shell - Exmouth Gulf Prawn Fishery - West Coast Deep Sea Crustacean	Letter with fact sheet and fishery map	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Defence	Email with fact sheet and map of defence zones	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Department of Transport	Email with fact sheet and map of shipping density	**Date:** 7 November 2017 **Feedback summary:** The Department thanked Woodside for the opportunity to comment on the activity. The Department stated that for all activities	Woodside acknowledges the advice and guidance note provided by the Department.	**Response/Action:** Woodside to email consultation materials as per address provided. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		correspondence must be sent to marine.pollution@transppport.com.au and copied this mailbox in the correspondence. The Department also attached an Industry Guidance Note for consultation and noted the requirement for a consultation period of four weeks.		
	Phone call	**Date:** 7 November 2017 **Feedback summary:** Woodside telephoned the Department to acknowledge the email received. Woodside noted the appropriate mailbox to direct consultation materials to and will use this in the future. Woodside also acknowledged receipt of the consultation guidelines. Woodside subsequently emailed the consultation materials to the mailbox requested by the Department.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required. **Attached: Appendix F**
	Email	**Date:** 7 December 2017 **Feedback summary:** The Department emailed to be consulted on any changes to oil spill response arrangements as per the Departments Industry Guidance Note.	Woodside advised that the First Strike Plan will be finalised in early 2018 and that the Department will be consulted as per the guidance note.	**Response/Action:** Woodside to consult the Department on the First Strike Plan. **Attached: Appendix F**
	Email and draft Oil Pollution First Strike Plan	**Date:** 9 March 2018 **Feedback summary:** The Department reviewed and provided the following comments on the draft Oil Pollution First Strike Plan: • Provide some more detail on the potential use of dispersant as a response option. • Provide further clarity on why dispersant efficacy appears to decrease over time until >240 hours where it then increases?	Woodside responded to the Department's feedback: • Provided details on the dispersants proposed, all have been tested for efficacy: • Dispersant efficacy results are based on laboratory testing. In the actual event of a spill Woodside will monitor dispersant effectiveness and use	**Response/Action:** No further action required. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		• The figure provided in Section 5 shows a pre-approved dispersant zone for the whole of Australia. Please provide a figure more relevant to the actual activity area? • DoT requests to be notified if dispersant effected oil is likely to enter State waters. • Provide detail on why mechanical dispersion is not considered a response option • Provide detail on the specific times to potential impact of the priority protection receptors. • Provide copies of Tactical Response Plans details in the FSRP	that to inform the operational NEBA. • A figure of the pre-approved dispersant zone relative to the NY facility was provided along with the basis for the definition of the dispersant application zone. • First Strike Response Plan (FRSP) contains requirement to notify DoT is spill is likely to extend to WA State waters. • Confirmed that mechanical dispersion is not considered a viable response strategy as it does not have a net environmental benefit. • Provided details of predicted time to contact with floating surface oil concentrations • Provided copies of tactical response plans.	
	Email	**Date:** 26 April 2018 **Feedback summary:** The Department advised it had no further feedback on the supporting documentation provided by Woodside.	The stakeholder raised no claims or objections	**Response/Action:** No further action required. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
Commonwealth Fisheries Association	Email with fact sheet and fishery map	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Western Australian Fishing Industry Council	Email with fact sheet and fishery map	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	**Response/Action:** No further action required.
Exmouth Community Reference Group (CRG)	Email with fact sheet and fishery map Presentation at CRG	**Date:** 8 November 2017 **Feedback summary:** Presentation by Woodside on proposed activities for the EP submission. Stakeholders raised no concerns during the presentation.	The stakeholders raised no claims or objections.	**Response/Action:** No further action required.
Quadrant Energy	Email with fact sheet Email with Operational Area map	**Date:** 20 November 2017 Quadrant thanked Woodside for the consultation materials. Quadrant advised it has no concerns with the revision and looks forward to continuing communications regarding operations in the region.	The stakeholder raised no claims or objections	**Response/Action:** No further action required. **Attached: Appendix F**
BHP	Email with fact sheet Email with Operational Area map	**Date:** 6 November 2017 **Feedback summary:** No response at the time of submission.	The stakeholder raised no claims or objections	**Response/Action:** No further action required.
Cape Conservation Group (CCG) (member of Exmouth CRG)	Email with fact sheet	**Date:** 4 December 2017 **Feedback summary:** Cape Conservation Group provided feedback via email that the information provided for the activity was limited.	Woodside acknowledged that CCG's feedback was similar to the feedback received from the Ningaloo Coast World Heritage Advisory Committee (NCWHAC).	**Response/Action:** Woodside to consider any further feedback received from CCG. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		CCG requested additional information about the proposal to re-inject affluent streams, including the volumes proposed, current disposal practices and evidence to support this practice has a reduced environmental impact. CCG also requested additional information about oil spill preparedness in relation to the 30 km pipeline from the oil field to the FPSO.	Woodside responded to CCG's feedback via response to NCWHAC.	
Ningaloo Coast World Heritage Advisory Committee (NCWHAC) (member of Exmouth CRG)	Email with fact sheet	**Date:** 5 December 2017 **Feedback summary:** NCWHAC provided advice about its role and establishment. NCWHAC provided feedback that the information provided for the activity was limited. NCWHAC advised the fact sheet map does not show the Ningaloo Coast World Heritage area boundary. NCWHAC referenced the NOPSEMA Guideline GL1721 for EP decisions and advised that potential impacts to World Heritage properties have not been addressed. NCWHAC advised that no consideration of potential impacts from light pollution for marine life has been addressed for the Outstanding Universal Value of the NCWHA 'aesthetically striking landscapes and seascapes.' NCWHAC advised that no information about the water re-injection pipe over the North Enfield Canyon was provided on the fact sheet. Information about importance of the canyon systems was also provided. NCWHAC requested additional information about oil spill preparedness in relation to	Woodside responded to the NCWHAC and CCG via letter. Woodside advised that the level of information requested is not typically provided in a consultation information sheet. An updated map, which included the Ningaloo Coast Heritage area boundary was provided. Woodside confirmed that World Heritage properties and values are assessed and any environment risk presented in the environment plan. Any potential impacts are managed to ALARP levels. Woodside confirmed that the environment plan does assess and manage environmental impacts associated with light. Woodside explained the purpose of the water injection flowline and confirmed that it will not be carrying PW for injection. Woodside confirmed that the environment plan includes a detailed assessment of the	**Response/Action:** No further action required. **Attached: Appendix F**

Organisation	Method	Feedback	Woodside Assessment	Woodside's Response
		the 30 km pipeline from the oil field to the FPSO. NCWHAC requested additional information about the proposal to re-inject affluent streams.	potential impact from a loss of containment. Woodside provided an overview of the preventative controls in place. Woodside confirmed that a comprehensive Oil Pollution Emergency Plan will be in place in the unlikely event a loss of containment occurs. The location of response equipment was also advised. Woodside provided an overview and advised that certain effluent streams from the new seawater filtration system will comingle with the PW.	
	Email	**Date:** 22 January 2018 **Feedback summary:** NCWHAC responded to Woodside and CCG via email. NCWHAC advised that the individual (committee representative) on the NCWHAC is affiliated through conservation interests and does not represent CCG within their role on NCWHAC. NCWHAC requested that future correspondence is kept separated between NCWHAC, CCG and Woodside; regardless of the similarities in feedback. NCWHAC advised that Woodside's response will be shared with all committee members and will revert if further information is requested.	Woodside acknowledged the advice about committee member roles and that future correspondence should be separated between the three organisations. Woodside advised that feedback from CCG and NCWHAC will be separated in the environment plan submission.	**Response/Action:** Woodside to ensure future correspondence with NCWHAC is separate from correspondence with CCG. Woodside to any consider future feedback if received from NCWHAC. **Attached: Appendix F**

Feedback from Interested Stakeholders on the Petroleum Activities Program

Organisation	Method	Feedback	Woodside assessment	Woodside's Response
Australian Fisheries Management Authority	Email with fact sheet and fishery map	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
AMSA (marine pollution)	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
Australian Conservation Foundation	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
AMOSC	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
Australian Petroleum Production & Exploration Association (APPEA)	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
Pearl Producers Association	Email with fact sheet and fishery map	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
RecfishWest	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
World Wildlife Foundation	Email with fact sheet	Date: 6 November 2017	Woodside will accept and	Response/Action: No further

Organisation	Method	Feedback	Woodside assessment	Woodside's Response
		Feedback summary: No response at the time of submission.	assess feedback from stakeholder post EP submission to NOPSEMA.	action required.
Wilderness Society	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
Australian Customs Service – Border Protection Command	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
Department of Biodiversity, Conservation and Attractions	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.
International Fund for Animal Welfare	Email with fact sheet	Date: 6 November 2017 Feedback summary: No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA.	Response/Action: No further action required.