Goodwyn Alpha (GWA) Facility Operations Environment Plan Summary

Production Division

October 2018

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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 Goodwyn Alpha (GWA) facility, hereafter referred to as the Petroleum Activities Program. The GWA Facility EP was approved by NOPSEMA on the 21st September 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 the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). This document summarises the GWA Platform 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 GWA facility is located in Commonwealth waters on the North West Shelf (NWS) of WA in Production Licences Area WA-5-L, WA-23-L, WA-57-L, WA-6-L, WA-1-L, WA-24-L and Pipeline Licences WA-2-PL, WA-9-PL, WA-13-PL, WA-27-PL, WA-24-PL. The GWA platform is situated approximately 138 km north-west of Dampier and 23 km south west of the North Rankin Complex (NRC) (**Figure 2-1**).

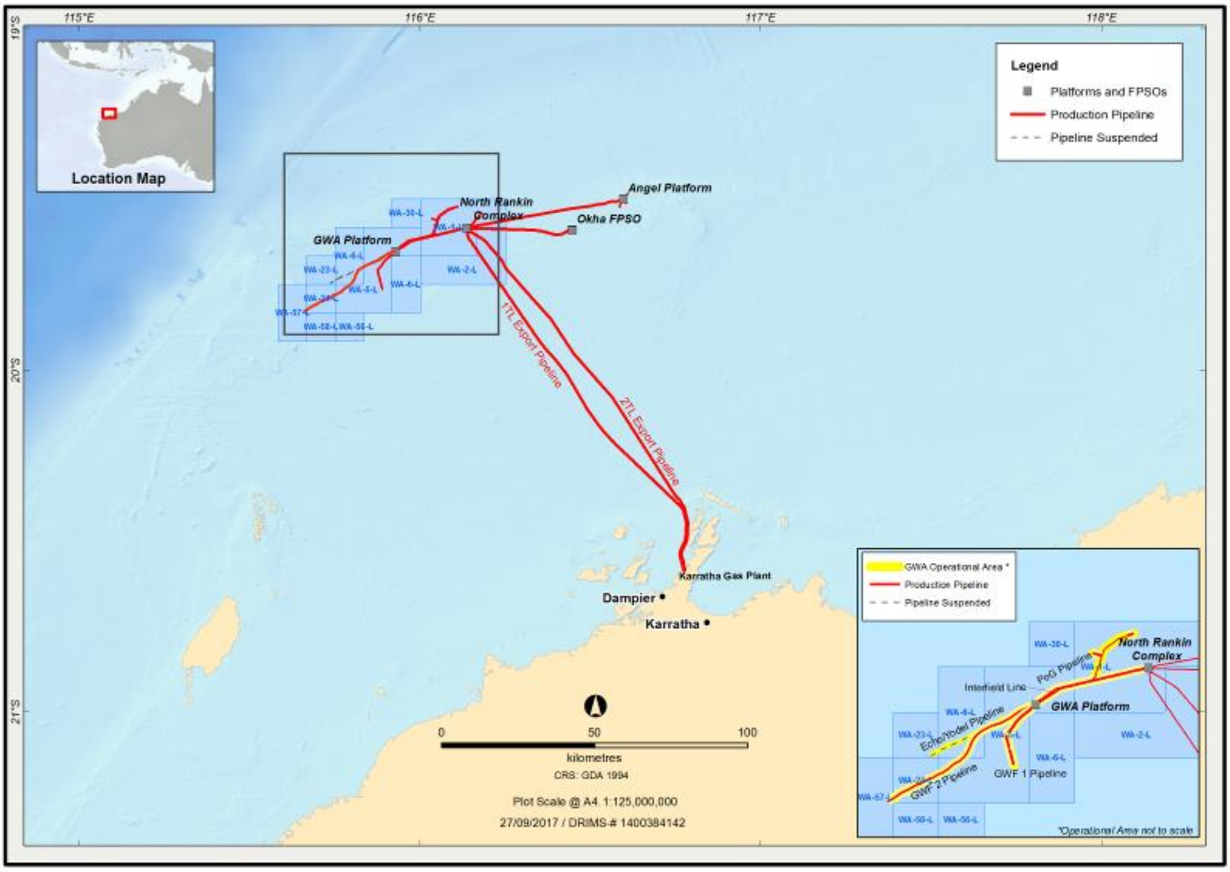

Figure 2-1: Location of the Petroleum Activities Program

The GWA facility is marked on nautical maps, surrounded by a 500 m petroleum safety zone. **Table 2-1** provides coordinates and permit areas of the GWA facility and associated infrastructure.

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

Activity	Water Depth (Approx. m LAT)	Latitude	Longitude	Production Licence
GWA facility platform	131 m	19° 39’ 07.936” S	115° 55’ 47.028” E	WA-5-L
Interfield Line (IFL)	133 m	-	-	WA-2-PL
Echo Yodel Pipeline	130 m	-	-	WA-9-PL
PoG Pipeline	130 m	-	-	WA-13-PL
GWF Phase 1 Pipeline	125 m	-	-	WA-24-PL

Activity	Water Depth (Approx. m LAT)	Latitude	Longitude	Production Licence
GWF Phase 2 Pipeline	130 m	-	-	WA-27-PL
PER 01 Well	131 m	19° 33’ 22.460” S	116° 02’ 06.799” E	WA-1-L
PER 02 Well	127 m	19° 31’ 11.700” S	116° 06’ 39.350” E	WA-1-L
PER 03 Well	130 m	19° 35’ 29.270” S	116° 02’ 33.259” E	WA-1-L
PER 04 Well	128 m	19° 31’ 06.500” S	116° 05’ 53.639” E	WA-1-L
Yodel 03 Well	136 m (Well suspended 30/06/2012)	19° 44’ 21.841” S	115° 44’ 49.063” E	WA-23-L
Yodel 04 Well	133 m (Well suspended 22/06/2012)	19° 44’ 48.040” S	115° 44’ 06.603” E	WA-23-L
GDA01 Well	125 m	19° 42’ 24.097” S	115° 52’ 33.203” E	WA-5-L
GDA02 Well	125 m	19° 42’ 24.097” S	115° 52’ 33.203” E	WA-5-L
TPA01 Well	200 m	19° 45' 44.652" S	115° 53' 25.253" E	WA-5-L
TPA02 Well	200 m	19° 45’ 44.996” S	115° 53’ 23.982” E	WA-5-L
TPA03 Well	113 m	19° 45’ 43.618” S	115° 53’ 23.986” E	WA-5-L
LPA-01 well	77 m	-19° 49' 46.337"	115° 39' 29.415"	WA-57-L
LPA-02 well	77 m	-19° 49' 46.453"	115° 39' 27.558"	WA-57-L
LPA-03 well	77 m	-19° 49' 45.485"	115° 39' 28.597"	WA-57-L
SRA-01 well	93 m	-19° 47' 38.715"	115° 46' 25.485"	WA-24-L
SRA-02 well	93 m	-19° 47' 39.845"	115° 43' 24.273	WA-24-L
KDA-01 well	122 m	-19° 45' 27.547"	115° 47' 07.026	WA-5-L
KDA-02 well	122 m	-19° 45' 27.547"	115° 45' 08.228"	WA-5-L
DOA-01 well	130 m	-19° 43' 00.124"	115° 48' 55.179"	WA-6-L

3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

The GWA facility (**Figure 2-1**) is owned by the NWS Joint Venture. Woodside is the nominated operator of the GWA facility. The facility was commissioned as an integrated drilling, production, utilities and accommodation platform. However, the GWA facility no longer has drilling capability and drilling does not form part of the scope of this EP.

The GWA facility produces dry gas and condensate from a series of reservoirs and associated subsea infrastructure. Two processing trains on the facility, Train 100 (T100) and Train 200 (T200), process the production fluids via a series of cooling, separation, compression and dehydration processes before being exported to the interfield line (IFL) and an onshore liquefaction facility at the Karratha Gas Plant (outside the scope of the EP).

The infrastructure covered by this EP includes the:

- GWA gas and condensate production platform;
- subsea infrastructure associated with or tied back to the GWA platform (including wells, wellheads, manifolds, pipelines, umbilicals, chemical supply lines, risers, flowlines etc.) including the GWF tiebacks (excluding subsea installation and cold commissioning activities); and
- IFL from GWA platform which joins the second trunkline (2TL) subsea near the North Rankin Complex (NRC) – note Petroleum Activities associated with 2TL and NRC are beyond the scope of this EP; and
- supporting activities associated with the activities defined above (e.g. vessel operations, helicopter transfers etc.).

3.2 Operational Area

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

- GWA facility and the area within a 500 m petroleum safety zone around the facility;
- The IFL from GWA facility to NRC covered by Pipeline Licence WA-2-PL and an area encompassing 1500 m around the infrastructure;
- EY subsea facilities, including the pipeline covered by Pipeline Licence WA-9-PL and an area within 1500 m around the infrastructure;
- PoG subsea facilities, including the pipeline covered by Pipeline Licence WA 13 PL and an area within 1500 m around the infrastructure;
- GWF-1 subsea facilities, including the pipeline covered by Pipeline Licence WA-24-PL back to GWA facility and an area within 1500 m around the infrastructure; and
- GWF-2 subsea facilities, including the pipeline covered by Pipeline Licence WA-27-PL and an area within 1500 m around the infrastructure.

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

3.3 Timing of the Activities

The GWA facility commenced production in 1995. The facility operates 24 hours a day, 365 days a year. Maintenance activities are undertaken as required to support the day to day operations of the GWA facility.

The end of life of the GWA facility is not predicted during the life of the EP. Tie-back opportunities are continuously being reviewed for Woodside's offshore facilities, which have the potential to extend the life of the facility. Any future decommissioning or drilling will be the subject to a separate EP.

3.4 Facility Layout and Description

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

3.4.1 Topsides

The GWA facility topsides structure consists of 11 modules with a plan view area of 4,000 m^2, extending 120 m from north to south and 55 m from east to west. The production deck is 25 m above sea level and the platform extends to approximately 175 m above sea level, to the top of the flare tower. The accommodation module (Module D, designated temporary refuge) is at the southern end of the platform and is segregated from the production systems by the utilities and drilling support modules.

The product export pipeline riser is located at the northern end of the platform. Two 'A' frame pedestal cranes are used to service the platform and dropped object protection is provided at critical topsides and subsea locations.

The drilling derrick on the GWA facility has been removed, however, the drilling package maintenance is in place to maintain equipment and structural safety and to ensure required function and integrity are maintained until fully removed from the facility.

3.4.2 Wells and Reservoirs

Goodwyn

- There are 19 platform wells on the GWA facility platform that produce from the Goodwyn reservoir.
- Extended reach horizontal wells were drilled up to 8 km from the platform to develop peripheral reservoir units.
- Tubing retrievable sub-surface safety valves (SSSV) and wireline retrievable SSSVs are installed on GWA facility wells as the primary down-hole safety system.
- These valves are controlled from the surface via a single control line or independent control lines located approximately 550 m below the wellhead.

Echo/Yodel

- Production from the EY field ceased in May 2012 and the two EY production wells were suspended in June 2012 by the installation of downhole plugs.
- The EY pipework downstream of the Riser Emergency Shutdown Valve (RESDV) was disconnected and reconfigured to connect the RESDV to the test header to provide a double block and bleed isolation, topsides pressure monitoring and access to flare.
- Integrity of the wells continues to be maintained through regular inspection until future decommissioning plans are finalised and executed.

Perseus / Searipple

- Three production wells in the Perseus reservoir and one well in the Searipple reservoir are tied back to GWA facility via a 16” diameter pipeline.
- Control and monitoring of the subsea wells is through an electro-hydraulic umbilical from GWA. Configuration of the subsea architecture allows for future extension of the PoG pipeline system through drilling of additional wells.
- The Perseus field is presently developed by both NRC and GWA facility and has an expected remaining life of approximately 30 years, which is based on current production forecasts and field expectation volumes.
- The reservoir drive mechanism is expected to be aquifer drive with a field life for Searipple of between two and five years.

Greater Western Flank

- GWF-1 comprises five gas production wells within the Goodwyn (GDA01 and GDA02) and Tidepole reservoirs (TPA01, TPA02 and TPA03). The production of these wells is provided for in this EP.
- GWF-2 spans across six reservoirs Keast/Dockrell, Sculptor, Rankin and Lady Nora/Pemberton and consists of eight wells. The production of these wells is provided for in this EP.
- Drilling, completions, pipeline installation and pre-commissioning activities associated with GWF-1 and GWF-2 are covered under separate EPs

3.4.3 Pipeline and Riser System

GWA Facility Export to NRC (IFL)

Dehydrated export gas and condensate is metered at the outlet of each production train on GWA facility prior to recombination and subsequent export into the IFL.

A sphere pig launcher is provided for servicing the pipeline. The launcher is designed for single launchings of spheres and for launching of pipeline inspection tools.

The pipeline/riser includes two key isolation valves. The RESDV is located in the splash zone and the sub-sea isolation valve (SSIV) is located on the jacket mudmat.

Concrete mattresses are provided to protect the export pipeline from dropped objects in the vicinity of the platform. Protection frames are provided around the riser and SSIV.

Echo/Yodel

The EY riser was disconnected from the EY valve and equipment skid (VES) and the low pressure train. The EY pipeline was subject to an extensive pigging campaign in 2016 to clean and remove hydrocarbons from the pipeline. A total of 5 pigs were launched from a subsea pig launcher and hydrocarbons and inhibited seawater were flushed to the GWA facility. Following completion of the pigging campaign a foam pig was launched from GWA. Nitrogen was used to propel the pig to circa 400 m from the GWA facility where it remains.

During the pigging campaign OIW samples were taken at regular intervals once the inhibited seawater arrived at the GWA facility. Sample analysis indicated the hydrocarbon level in the inhibited seawater was ~6 ppm at completion of pigging. Hydrosure was selected and approved in accordance with the chemical assessment process outlined in **Section 3.8.**

A section of the EY pipeline will be removed. When removing a ~25m section of EY pipeline it is envisaged that nitrogen with limited amounts of treated seawater (which may have passed through the foam pig) will be released to the environment. The spool removal scope includes for an appropriately designed plug assembly with a design life of circa 20 years to be inserted into both ends of the remaining pipeline.

Integrity of the EY riser will continue to be maintained through regular inspection and maintenance until future re-use or decommissioning plans are finalised. Activities associated with EY pipeline, re-use or decommissioning will be the subject of separate EPs.

Perseus/Searipple

The PoG pipeline currently accesses the platform using a 16” riser located on the north face of the GWA facility platform (to the east of the EY riser caisson). The riser is protected from ship impact by routing it within the GWA facility jacket structure from a depth below that which it is vulnerable to ship impact (approximately -12 m below mean sea level). In an emergency, this pipeline can be isolated from the riser using the SSIV located on the seabed approximately 75 m north of the platform, and the riser can be isolated from the topsides piping using the RESDV, located beneath Level 0 at +18 m LAT.

To allow for the tie-in of the proposed GWF-1 tieback, the PoG riser was re-routed to the ex-EY VES and the low pressure train. The GWF-1 riser was connected to the ex-PoG VES and the high pressure train.

GWF Pipelines

The GWF-1 wells are tied back to the GWA facility via a 16”, 16.3 km pipeline which terminates the GWF-1 SSIV. The SSIV is connected via a series of spools to the GWF riser located in the centre of the platform and is therefore protected from ship impact by the GWA facility jacket structure from a depth below that which it is vulnerable to ship impact (approximately -12 m). In an emergency, this pipeline can be isolated from the riser using the SSIV located on the seabed approximately 40 m from the platform.

The GWF-2 tieback consists of a 35 km pipeline which is tied into the existing GWF-1 SSIV. Hydrocarbons from GWF-2 are comingled with GWF-1 and routed through the common GWF spools and riser for further processing topside.

3.4.4 Subsea Infrastructure

The main components of subsea infrastructure include wells, Xmas trees, manifolds, umbilicals, risers and flowlines.

The subsea system is controlled from the GWA facility platform through the following components:

- Jumpers and umbilicals which provide hydraulic and electric power, communications and chemical supplies between the platform and subsea components through a number of cables and tubes. Umbilicals run between the platform and the Subsea Distribution Units (SDU) and Umbilical Termination Assemblies (UTA), Umbilical Termination Baskets (UTBs) and jumpers run between SDUs/UTAs/UTBs and the manifold;
- Valves which control subsea operations and processes;
- Chokes which control pressure and flow rates of hydrocarbons; and
- Subsea Control Modules (SCM) which are sealed and pressure compensated electro-hydraulic units (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 either a Remote Operated Vehicle (ROV) or divers.

3.5 Operational Details

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

3.5.1 Manning and Modes of Operation

GWA facility is permanently manned. The Central Control Room (CCR) is manned 24 hours per day. Other activities which affect manning levels, are:

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

Normal operations at GWA facility fall under any one of the following modes of operation:

- Production and maintenance, including subsea IMR activities;
- Production and well maintenance;
- Production and major projects; and
- Remote operations.

These modes of operation are described below. Production, maintenance and project activities may occur concurrently.

Production and Maintenance

Production and maintenance covers hydrocarbon receipt, processing, export and supporting operations. Inspection, maintenance and repairs, including those undertaken subsea, are undertaken to maintain production within the platform and subsea infrastructure design constraints.

Production and Well Maintenance

Production and well maintenance involves well workover or interventions concurrent with production activities. Workover/well intervention may take place utilising a hydraulic workover unit.

Major Projects

Major projects involve refurbishment, modification or major maintenance on the facility. The Projects function are responsible for undertaking these projects.

Remote Operations

While the GWA facility is typically operated as a manned facility, Woodside may de-man GWA facility (e.g. as a precautionary safety measure during severe cyclones). Operation of the GWA facility may be maintained during de-manning via a Remote Operation Station at the KGP.

Whilst remotely operated, the GWA facility will continue to produce at stable rates which will be established prior to de manning the facility. Operating at stable rates means production will remain steady with no major process changes. This will minimise the potential for process upsets while operating in remote mode.

3.5.2 Process Description

Production Process

The GWA facility receives well fluids (gas, condensate and associated PW) from the production wells for topside processing via gas dehydration and condensate dewatering. The facility then exports the processed gas and condensate onshore to the KGP.

The GWA facility has two processing trains (T100 and T200). GWF and PoG field production is processed and dehydrated on GWA facility using existing processing capacity, both PoG and GWF are tied into both T100 and T200, while GWA facility flows to T100.

The gas export compressor takes suction at the lower operating pressures and returns the gas to export pressure allowing it to be routed onshore via the interfield pipeline. The export compression package (compressor, power generation turbine and associated equipment) includes the following equipment:

- Export compressor and aftercooler;
- Gas generator;
- Power turbine;
- Reduction gearbox;
- Lube oil systems;
- Dry gas seal system; and
- Suction Scrubber.

Retirement of T200 Stripping Gas Compressor

The GWA facility T200 Stripping Gas Compressor (SGC) was mothballed in the April 2017 Shutdown. The benefits of retiring the compressor are a reduction in production outages caused by trips, savings in ongoing maintenance costs and reduced fuel gas consumption and emissions. Taking one of the stripping gas compressors offline has resulted in a power saving of approximately 860 kW.

Flare Systems

The GWA facility platform has two flare systems, the High Pressure (HP) Flare and the Low Pressure (LP) Flare. The main purpose of the flare systems is to safely discharge gas streams during an emergency depressurisation. However, there are also a number of process streams which continuously pass gas to the flare, such as gas flashed from the PW, and stripping gas used in the glycol regeneration process. Other streams intermittently flow to the flare, such as during maintenance activities, and when vessels are depressurised and purged.

The flow of gas through each of the HP and LP flare networks is measured using separate ultrasonic flow meters with pressure and temperature compensation. A small portion of the fuel gas stream is used for the flare purges to exclude air.

3.5.3 Produced Water System

Produced water (PW) is brought to the surface from the reservoir and is separated out from the hydrocarbon components during the production process and discharged to the marine environment.

In 2016, the GWA facility discharged approximately 1013 m^3 of PW per day. PW rates may change in the future should a well water out, or a ‘wet’ well or field be tied in. Overall it is expected that PW rates will increase as the field ages.

The PW system directs all PW streams from the process areas to the PW degasser to remove dissolved gas and condensate before disposal overboard via the Hazardous Closed Drains Caisson. Recovered condensate is skimmed off the top of the degasser vessel liquids and returned to the process via the Closed Drain Break Drum. Residual oil that may accumulate in the hazardous closed drains caisson is skimmed off the water and pumped to ISO drums for onshore disposal.

Adsorbent hydrocarbon filters to remove dispersed oil from the PW stream are installed on GWA. The system is used sparingly and primarily to manage oil in water (OIW) upsets. Adsorbent filters are automatically activated when the high level OIW alarm is activated by the OIW analyser. This occurs instantaneously when the OIW concentration goes above 30 mg/l. The filters are manually turned off when OIW concentrations are reduced. The drains from the filters are routed to the existing closed drain system, thereby removing oil from the treatment system. Given the degasser is between the adsorbent filters and the OIW analyser, flow from the OWDS to the degasser is not continuous, and there is variability over time in OIW contribution from the process trains, it is difficult to quantify the reduction in OIW achieved by activating the OIW filters.

The drains from the filters are routed to the existing closed drain system, while the hydrocarbon relief is routed to the LP flare, via the oily water drains system.

PW Discharge Oil in Water Monitoring

The measurement of oil in water (OIW) in the PW stream is undertaken prior to discharge to the ocean. On the GWA facility, OIW is measured using a continuous online OIW analyser. The analyser is designed specifically for offshore operations and detects and measures soluble hydrocarbons (aromatic hydrocarbons) in water.

3.5.4 Drainage Systems

The open and closed drains system consists of both hazardous and non-hazardous open drains. The open drains system is required for disposal of water and hydrocarbons, which are at atmospheric pressure (e.g. deck water). Drains from hazardous areas are totally segregated from drains from non-hazardous areas in order to prevent ingress of gases into a non-hazardous area via the drains system.

Operational process and non-process discharges, some maintenance activities discharges and potential spills contained within the hazardous open drain system are routed to the hazardous open drains caisson. The hazardous open drains caisson primary and back up instrumentation provide live visibility of calculated hydrocarbon inventories in the caisson to prevent underflow and is equipped with a sump pump to recover any hydrocarbons which may accumulate. These liquids are transferred to an ISO container for disposal onshore.

The Closed Drains Caisson forms part of the closed drain system used for PW disposal outlined in **Section 3.5.3**.

3.5.5 Utility Systems

The GWA facility has in place a range of utility systems to support operations including;

- Platform Lighting;
- Heating Ventilation and Air Conditioning System;
    - Refrigerants associated with the HVAC system are recorded and managed via Woodside's Refrigerant Management Register available on Woodside's intranet site. A significant engineering and modification project has been implemented in recent years to systematically work through the assessment and change-out of ozone depleting substances (ODS) inventories (i.e. R22) present on the GWA facility platform to minimise ODS use. Recent execution has successfully delivered an 85% elimination of R22 stocks, with only a limited number of small inventory systems remaining (4.7 kg each).
    - The larger chiller and HVAC systems with historical inventories of R22 ranging from 10-60 kg charges have been successfully substituted with non-ODS refrigerants. Overall, across 30 systems: 519 kg (out of a total of 594 kg) of R22 has been

successfully changed-out on the GWA facility platform. The risk based approach taken sees only the small inventory systems remaining (limiting the potential for fugitive losses to environment for each isolatable inventory), with an execution strategy in place to complete these during 2018 maintenance campaigns.

- Seawater Treatment System;
- Seawater System;
- Tempered Water System;
- Potable Water;
- Power Generation;
- Sewage and Putrescible Wastes; and
- Sand Management.

3.5.6 Operational Flaring

Flaring is expected to occur during a range of operational circumstances; key operational flaring events are explained in further detail in the following sections. Annual internal facility flare targets are set based on operational activities planned for the year. This target is used to assess facility flare performance.

Normal Operations

A relatively small quantity of gas is required to be continuously flared associated with purge and pilot of the flare system and disposal of waste streams which are not recovered to the process.

The continuous flows to the LP flare are:

- Flare pilot;
- LP flare header and storage tank purges; and
- Glycol regeneration process, including still column overheads and flash drum.

The continuous flows to the HP flare are:

- Flare pilot;
- HP Flare Pilot;
- Flash gas from glycol flash drums (which is under on/off level control);
- Flash gas from PW degasser;
- Flash gas from scrubber vessels, including fuel gas, stripping gas compressor, T200 export compressor and the glycol contactor integral suction scrubbers (all under on/off level control); and
- Leakage past flare header valves such as PSVs and blowdown valves (BDVs).

Estimated Flare Volumes

The amount of gas that may be flared on an annual basis is a dependent of continuous and intermittent process sources, planned activities requiring flaring, and unplanned process upsets. The estimated annual amount of gas flared ranges between 10,000 and 17,000 tonnes.

3.5.7 Lifting Operations

Two pedestal cranes are provided on the GWA facility, one on the east side and one on the west side. Both cranes are of ‘A’ frame design and driven by diesel engines. A 16 tonne beam mounted electric hoist is also located in module A, level one for the removal and installation of the seawater and fire water pumps.

3.5.8 Diesel Bunkering

Low sulphur diesel is transferred to GWA facility in bulk from supply vessels via the east and west bunkering stations. Diesel is filtered prior to entering the storage facilities in the east and west crane pedestals. The diesel is pumped from this location to the filter/coalescer package for clean-up before distribution to the user areas. Diesel is metered and distributed to the users via a continuously pressured ring main. Unused diesel is recycled back to the crane pedestals. Each user is isolated from diesel supply interruptions by the provision of break tanks.

The system supplies purified diesel fuel, free of water and solid impurities, at the required pressure and flow rate to:

- Turbine generators (back up to fuel gas);
- Emergency generator;
- Drilling generator;
- East and west cranes;
- Firewater pumps; and
- Lifeboats.

3.5.9 Safety and Emergency Systems

A range of safety features and emergency systems have been integrated into the design and operation of the GWA facility to manage safety risk. Based on Woodside Health and Safety Design Premises for Hydrocarbon Facilities, risk management measures have been grouped into the following categories:

- Prevention;
- Detection;
- Control; and
- Mitigation.

The safety features and emergency measures in place of the GWA facility are listed in **Table 3-1**.

Table 3-1: GWA Facility Safety Features and Emergency Systems

Category	Description
Prevention	Inherently safe design (leak minimization, layout) Dropped object / impact protection (including vessel collision avoidance) Structural design Material selection and corrosion control
Detection	Fire, gas and smoke detection (including manual alarm call points (MACs))
Control	Process control system Ignition control Depressurisation systems Passive fire protection Active fire protection

Category	Description
	Heating, ventilation and air conditioning
Mitigation	Escape and evacuation routes Safety Critical Buildings Emergency power and UPS Emergency and escape lighting Critical communications systems Evacuation and rescue facilities and equipment

3.6 Vessels

Platform support vessels and subsea support vessels are used in support of the GWA facility. Platform support vessels are utilised in a support capacity for transferring personnel, material and equipment to and from the facility (e.g. the *Mermaid Strait*). Vessels supporting the facility may vary depending on vessel schedules and availability.

The current schedule is for a vessel to visit the facility weekly. While in the field, the vessel also backloads materials and segregated waste for transportation back to the King Bay Supply Base (KBSB) in Karratha, as well as carrying out standby duties including during helicopter operations and working over the side activities while in the field.

Subsea support vessels are also used for field work such as subsea inspection, maintenance and repair 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 the event of an emergency.

3.7 Helicopter Operations

Helicopters are the primary means of transporting passengers and/or urgent freight to/from the GWA facility and support vessels. They are also the preferred means of evacuating personnel in the event of an emergency. Helicopter support is principally supplied from Karratha Airport; there are typically 5-7 transfers per week, depending on operational requirements.

3.8 Hydrocarbon and Chemical Inventories and Selection

3.8.1 Hydrocarbons

Non process inventories of hydrocarbons used on the GWA facility are diesel and lube oil/seal oil/hydraulic oil.

3.8.2 Chemical Usage

Chemicals are utilised on the GWA 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
- Triethlene Glycol (TEG)

- Monoethylene Glycol (MEG)
- Biocide
- Scale Inhibitor (provision for future use)
- Subsea Control Fluid
- Demulsifier
- 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 to the environment (PLONOR), no further control is required. (Such chemicals do not represent a significant impact on the environment under standard use scenarios and therefore, are considered ALARP and acceptable)
- If other OCNS rated or non-OCNS rated operational chemicals are selected, the chemical will be assessed 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 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.

3.9 Subsea Inspection Maintenance and Repair Activities

3.9.1 IMR Activities

A range of subsea inspection, monitoring, maintenance and repair activities (referred to as IMR) may be undertaken during the operations of GWA. 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 dynamic positioning (DP) system 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;
- Marine growth removal;
- Sediment relocation;
- Hotstab change out;
- Repair/replacement of corrosion protection layer;
- Span rectification;
- Cycling of valves;
- Choke change out;
- Subsea Control Modules (SCM) change out;
- Jumper and umbilical replacement;
- Riser and flowline repair/replacement;
- Tree cap change out;
- Spool repair/replacement; and
- Suspension of redundant equipment.

3.9.2 Platform Well Management and Maintenance Activities

Well management and maintenance for platform-based wells may be undertaken from the GWA facility, and may include:

- Well intervention: well intervention activities may be undertaken for reservoir surveillance, enhancing productivity / injectivity, assessing wellbore condition and restoring will integrity. Routine wellhead maintenance is conducted regularly on all surface wellheads/trees.
- Well workover: well workovers generally involve recovery and re-installation or replacement of production / injection completion strings.
- Well kill: well kill is an operation to displace reservoir fluids from the wellbore by replacing them with a weighted fluid system (kill fluid) to achieve zero and stable shut-in tubing head pressure. A well kill may be required in the event that well integrity is compromised and provides a means of mitigation until such time that a more permanent fix can be implemented to re-instate full well integrity. A well kill may also be carried out to facilitate planned, routine well workover and intervention activities.

Chemical Use and Discharges

Interventions, workovers and well kills may typically involve the use and discharge of chemicals which may include, but not limited to:

- Glycol;
- High viscous (hi-vis) polymer pills or sweeps;
- Surfactant and / or solvent pills or sweeps;
- Fluid loss control (FLC) and / or lost circulation material (LCM) pills;

- Seawater, raw or inhibited with any combinations including biocide, oxygen scavenger, caustic or soda ash; and
- Brine, KCl / NaCl, raw or inhibited with any combinations including biocide, oxygen scavenger, caustic or soda ash.

Any chemicals or fluids used for the above operations will be selected in accordance with Woodside's chemical selection and approval procedures.

Well Clean-up

When commissioning wells or conducting well workovers, there is a need to clean-up the remaining fluids left behind in the well, which consists of chemicals, residual hydrocarbons or other foreign fluids in the wellbore.

- Gas: routed into the production process where possible, or flared if unsuitable;
- Fluids: routed to the HP flare KO drum which discharges liquids to the hazardous closed drain system; and
- Wastes (may include fluids and sand / solids): managed as appropriate based on composition. Solids are separated for onshore disposal. An additional strainer may be placed in the flowlines prior to the main separators to remove any large debris that may be present within the wellbore.

Well Clean Up activities are managed within 30mg/l OIW concentrations.

High Water Cut Well Unloading and Production

Water production on GWA facility wells has increased over time, resulting in a number of high water cut wells. There are currently three high water cut wells available for production without any further well intervention required. There are two further high water cut wells which could be available for production following successful intervention. Routine GWA facility water production operates under a 30 mg/L OIW limit, which applies in the short term over a 24-hour rolling average.

In particular, well unloading of long-term shut-in high water cut wells generally require a faster than usual bean-up rate to ensure a successful kick-off of these wells and unload the formation water in the wellbore. This rapid bean up does not allow sufficient water residence time in the separation process units potentially resulting in higher than normal instantaneous OIW values. It is necessary to increase water production from these wells temporarily to understand the long-term OIW performance of the facility when producing high water cut wells. Having temporarily high and unstable water production rates from the well and through the topsides facilities during this transient period is expected. Flexibility to allow for temporary elevated OIW levels is required until steady production is established and OIW can return to the 30 mg/L, 24-hour rolling average.

To manage non-routine high water cut well unloading activities, Woodside has adopted a 100 mg/L 24h rolling average, combined with a monthly 30 mg/L OIW average. Woodside will monitor OIW concentrations, and if the daily averages indicate that the monthly 30 mg/L limit is threatened, then high water cut wells will be either choked back or shut-in.

Woodside will complete trials of the high water cut well unloading and production activity to determine whether currently producing high water cut wells are capable of sustainable production within a 30 mg/l OIW limit. While the frequency that this activity will occur will depend on the number of facility shutdowns in a year, once the initial trials are completed it is anticipated that high water cut well unloading and production will not occur more than three times a year.

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 130 km north-west of Dampier 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 North West Shelf Province (NWS Province), in water depths of approximately 79-131 m. The NWS Province is part of the wider North West Marine Region (NWMR) as defined under the Integrated Marine and Coastal Regionalisation of Australia. The NWS Province encompasses the continental shelf between North West Cape and Cape Bougainville and varies in width from approximately 50 km at Exmouth Gulf to greater than 250 km off Cape Leveque and includes water depths of 0–200 m.

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 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 on the outer continental shelf between 79 and 131 m of water. The bathymetry within the Operational Area is generally flat, which is consistent with the broader NWS Province shelf region. The seabed has a gentle (0.05°) seaward gradient extending to a steep distal slope approximately 200 to 300 km offshore in water depths of around 200 m. The continental slope then descends more rapidly from the shelf edge to depths greater than 1000 m to the north-west.

Sediments in the Operational Area are broadly consistent with those in the NWS Province, with typically low levels of potential contaminants of geogenic origin (often below laboratory limits of detection), with the exception of localized areas of elevated barium. Carbonate sediments typically account for the bulk of sediment composition, with both biogenic and precipitated sediments present on the outer shelf. Beyond the shelf break, the proportion of fine sediments increases along the continental slope towards the Exmouth Plateau and the abyssal plain.

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.

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 zooxanthellate corals. Given the depth of water in the Operational Area (between approximately 79 and 131 m), these benthic primary producer groups will not occur in the Operational Area but are widespread within the ZoC in relatively shallow waters (typically <30 m water depth), such as the mainland, offshore islands, reefs and sedimentary banks.

Woodside has collected numerous biological grab samples of the unconsolidated seabed sediments at the NRC (eastern end of the Operational Area) and the surrounding area, as well as additional sampling throughout the broader region (Heyward et al. 2001, Sinclair Knight Merz 2007a). Studies have revealed that infauna associated with soft unconsolidated sediment habitat in the NWS is widespread and well represented along the continental shelf and upper slopes.

Benthic grab sampling around the GWA facility platform revealed a low abundance, high variability and diversity of infauna dominated by polychaetes and crustaceans, with results indicating higher species richness and abundance at the GWA facility platform compared to NRC. More recent sampling for the GWF-1 project also showed that the area supports invertebrate fauna dominated by burrowing polychaete worms (Phylum Annelida) and crustaceans (Phylum Crustacea) (RPS Environment and Planning 2012a).

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. Corals are known to occur at Rankin Bank (approximately 3.5 km from the Operational Area at the closest point).

Seagrass beds and macroalgae habitats are widespread in shallow waters in the wider ZoC and are widely distributed in shallow coastal waters that receive sufficient light to support seagrasses and macroalgae. Shark Bay hosts significant seagrass beds, which support a significant population of dugong.

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 isolated sections of the Ningaloo coast, the Pilbara islands and shoreline, and Shark Bay.

Surveys in the region indicate that deep water habitats consist primarily of bare unconsolidated carbonate sediments supporting a sparse assemblage of deposit and filter feeding organisms, including glass sponges, urchins, sea cucumbers, sea stars and crustaceans (Heyward et al. 2001, Sinclair Knight Merz 2007b, URS 2010). Benthic fauna is closely associated with substrate type, with areas of hard substrate supporting more diverse epibenthic communities. Areas of deep water hard substrate have been observed on the continental shelf, including pinnacles which are possibly formed by deep water coral *Lophelia* spp., and exposed cliffs of sedimentary rock. Such areas may provide substrate for attachment of sessile organisms and provide habitat for other fauna such as fish. The Ancient Coastline at 125 m Depth Contour KEF (within the Operational Area) may host areas of hard substrate, as will Rankin Bank and the Glomar Shoals (3.5 km west and 44 km east of the Operational Area respectively).

4.3.2 Pelagic and Demersal Fish Populations

The presence of subsea infrastructure associated with the GWA facility has resulted in the development of demersal fish communities that would otherwise not occur in the Operational Area (McLean et al. 2017). Given the continental shelf waters of the Operational Area, pelagic species will also be present. The Ancient Coastline at 125 m Depth Contour KEF overlaps the Operational Area, which includes areas of hard substrate that may support relatively diverse demersal fish assemblages. Rankin Bank and the Glomar Shoals KEF (3.5 km west and 44 km east of the Operational Area respectively) have also been identified as supporting high demersal fish richness and abundance (AIMS 2014a). The Continental Slope Demersal Fish Communities is a KEF in the vicinity of the Operational Area (approximately 25 km west at the closest point).

Fish species in the NWMR (including the Operational Area and the ZoC) comprise small and large pelagic and 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 travel extensively.

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, 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 2005a) with periodic upwelling throughout the year.

4.3.4 Species

A total of 117 EPBC Act listed species considered to be MNES (i.e. listed as threatened or migratory) were identified as potentially occurring within the Wellhead Operational Area (**Table 4-1**). Of these 70 are considered threatened marine species and 74 migratory species under the EPBC Act.

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 borealis	Sei whale	Vulnerable	Migratory	Ops Area
Balaenoptera edeni	Bryde's whale	N/A	Migratory	
Balaenoptera musculus	Blue whale	Endangered	Migratory	
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	
Orcinus orca	Killer whale, orca	N/A	Migratory	
Physeter macrocephalus	Sperm whale	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/Timor Sea populations)	N/A	Migratory	
Balaenoptera bonaerensis	Antarctic minke whale, dark-shoulder minke whale	N/A	Migratory	ZoC
Dugong dugon	Dugong	N/A	Migratory	
Eubalaena australis	Southern right whale	Endangered	Migratory	
Neophoca cinerea	Australian sea-lion, Australian sea lion	Vulnerable	N/A	
Sousa chinensis	Indo-Pacific humpback dolphin	N/A	Migratory	
Reptiles				
Caretta	Loggerhead turtle	Endangered	Migratory	Ops Area
Chelonia mydas	Green turtle	Vulnerable	Migratory	
Dermochelys coriacea	Leatherback turtle, leathery turtle, luth	Endangered	Migratory	
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	
Natator depressus	Flatback turtle	Vulnerable	Migratory	
Aipysurus apraefrontalis	Short-nosed sea snake	Critically endangered	N/A	ZoC
Sharks, Fish and Rays				
Anoxypristis cuspidata	Narrow sawfish, knifetooth sawfish	N/A	Migratory	Ops Area
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)	Vulnerable	N/A	
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 alfredi	Reef manta ray, coastal manta ray, inshore manta ray, Prince Alfred's ray, resident manta ray	N/A	Migratory	
Manta birostris	Giant manta ray, chevron manta ray, pacific manta ray, pelagic manta ray, oceanic manta ray	N/A	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Pristis zijsron	Green sawfish, dindagubba, narrowsnout sawfish	Vulnerable	Migratory	
Rhincodon typus	Whale shark	Vulnerable	Migratory	
Lamna nasus	Porbeagle, mackerel shark	N/A	Migratory	ZoC
Pristis clavata	Dwarf sawfish, Queensland sawfish	Vulnerable	Migratory	
Pristis	Freshwater sawfish, largetooth sawfish, river sawfish, Leichhardt's sawfish, northern sawfish	Vulnerable	Migratory	
Birds				
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Ops Area
Anous stolidus	Common noddy	N/A	Migratory	
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	
Calidris canutus	Red knot, knot	Endangered	Migratory	
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	
Fregata ariel	Lesser frigatebird, least frigatebird	N/A	Migratory	
Fregata minor	Great frigatebird, greater frigatebird	N/A	Migratory	
Numenius madagascariensis	Eastern curlew, far eastern curlew	Critically endangered	Migratory	
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	N/A	ZoC
Ardenna carneipes	Flesh-footed shearwater, fleshy-footed shearwater	N/A	Migratory	
Ardenna pacifica	Wedge-tailed shearwater	N/A	Migratory	
Arenaria interpres	Ruddy turnstone	N/A	Migratory	
Calidris alba	Sanderling	N/A	Migratory	
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	
Calidris ruficollis	Red-necked stint	N/A	Migratory	
Calidris tenuirostris	Great knot	Critically endangered	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Charadrius leschenaultii	Greater sand plover, large sand plover	Vulnerable	N/A	
Charadrius veredus	Oriental plover, oriental dotterel	N/A	Migratory	
Diomedea amsterdamensis	Amsterdam albatross	Endangered	Migratory	
Diomedea exulans	Wandering albatross	Vulnerable	Migratory	
Glareola maldivarum	Oriental pratincole	N/A	Migratory	
Hydroprogne caspia	Caspian tern	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	Black-tailed godwit	N/A	Migratory	
Macronectes giganteus	Southern giant-petrel, southern giant petrel	Endangered	Migratory	
Macronectes halli	Northern giant petrel	Vulnerable	Migratory	
Numenius phaeopus	Whimbrel	N/A	Migratory	
Onychoprion anaethetus	Bridled tern	N/A	Migratory	
Pandion haliaetus	Osprey	N/A	Migratory	
Papasula abbotti	Abbott's booby	Endangered	N/A	
Phaethon lepturus	White-tailed tropicbird	N/A	Migratory	
Pluvialis squatarola	Grey plover	N/A	Migratory	
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A	
Rostratula australis	Australian painted snipe	Endangered	N/A	
Sterna dougallii	Roseate tern	N/A	Migratory	
Sternula albifrons	Little tern	N/A	Migratory	
Sternula nereis	Australian fairy tern	Vulnerable	N/A	
Sula leucogaster	Brown booby	N/A	Migratory	
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	N/A	
Thalassarche cauta	Tasmanian shy albatross	Vulnerable	Migratory	

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area/ZoC
Thalassarche cauta[1]	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	
Xenus cinereus	Terek sandpiper	N/A	Migratory	
Arenaria interpres	Ruddy turnstone	N/A	Migratory	
Calidris alba	Sanderling	N/A	Migratory	
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	
Calidris ruficollis	Red-necked stint	N/A	Migratory	
Calidris tenuirostris	Great knot	Critically endangered	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 MNES were identified as potentially occurring within the Operational Area including the common sandpiper, common noddy, sharp-tailed sandpiper, red knot, pectoral sandpiper, streaked shearwater, lesser frigatebird, great frigatebird and eastern curlew.

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.

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 NWS Province. 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. No Ramsar wetlands were identified within the Operational Area or wider ZoC. The nearest Ramsar wetland is Eighty Mile Beach, approximately 379 km east of the Operational Area and beyond the wider ZoC.

[1] *T. cauta cauta* is also listed as *T. cauta*

Marine Mammals

The pygmy blue whale migration BIA off the coast of Western Australia lies approximately 27 km west of the Operational Area at the closest point and lies within the wider ZoC. Based on pygmy blue whale migration timing, the species may occur in the wider ZoC between April and August (north-bound migration) and October to January (south-bound migration). The humpback whale annual migration was identified as occurring within the Operational Area and the wider ZoC. The species undertakes regular seasonal migrations between feeding grounds in the Southern Ocean and breeding and calving grounds off northern Western Australia, 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. Only small numbers of whales were observed to occur in the deeper offshore waters.

Noise logger deployment conducted near the GWF-2 tieback detected humpback whales present at the end of September, likely migrating south, and from June to mid-August in deeper water, nearer to the continental shelf, likely migrating north (RPS Environment and Planning 2012b). The southward migration of cow/calf pairs is slightly later during October (extending into November and December). During the southbound migration, it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast than the northern migratory path. Humpback whales may occur within the Operational Area and wider ZoC during these migration periods.

There is the potential for nine species of cetacean, including Sei whale, Bryde's whale, fin whale, sperm whale, Antarctic Minke whale, southern right whale, killer whale, spotted bottlenose dolphin and indo-pacific humpback dolphin may 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. A dugong BIA for breeding, calving foraging and nursing lies within the wider ZoC, approximately 246 km south-east of the Operational Area.

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. A flatback turtle internesting BIA overlaps the Operational Area, and a number of BIAs have been identified in the wider ZoC, including:

- Green turtle: Internesting buffer, internesting, nesting, mating, foraging, aggregation and basking BIAs (the nearest of which is approximately 32 km from the Operational Area at the closest point);
- Hawksbill turtle: Internesting buffer, foraging, mating, nesting and internesting (the nearest of which is approximately 35 km from the Operational Area at the closest point);
- Flatback turtle: Foraging, nesting, mating and aggregation BIAs (the nearest of which is approximately 55 km from the Operational Area at the closest point); and
- Loggerhead turtle. Internesting buffer and nesting BIAs (the nearest of which is approximately 45 km from the Operational Area at the closest point).

Eighteen species of sea snakes were identified as potentially occurring within the GWA facility wider ZoC. One of these species, the short-nosed sea snake, is listed as Critically Endangered. This species has primarily been recorded at Ashmore Reef and Cartier Island on the Sahul Shelf, which lie over 1000 km from the Operational Area and beyond the wider ZoC. 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 narrow sawfish, grey nurse shark, great white shark, shortfin mako, longfin mako, reef manta ray, giant manta ray, green sawfish, whale shark and dwarf 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, 27 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.

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 National Shipwreck Database is McDermott Derrick Barge No. 20, which lies approximately 41 km south of 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, Western Australia, 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, and the Dirk Hartog Landing Site 1616 - Cape Inscription Area Historic Heritage Place.

No Ramsar wetlands overlap the Operational Area or wider ZoC.

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;
- Western Deepwater Trawl Fishery;
- Western Skipjack Fishery; and
- Western Tuna and Billfish Fishery

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

- Exmouth Gulf Managed Prawn Fishery;
- Gascoyne Demersal Scalefish Fishery;
- Mackerel Managed Fishery;
- Marine Aquarium Managed Fishery;
- Nickol Bay Managed Prawn Fishery;

- Onslow Prawn Managed Fishery;
- Pearl Oyster Managed Fishery;
- Pilbara Demersal Scalefish Fishery;
- Shark Bay Scallop Fishery;
- Shark Bay Prawn Managed Fishery;
- Shark Bay Crab Managed Fishery;
- Shark Bay Beach Seine and Mesh Net Managed Fishery; and
- South West Coast Salmon Managed Fishery;
- Specimen Shell Managed Fishery;
- West Australian Abalone Fishery;
- West Coast Demersal Scalefish Fishery;
- West Coast Deep Sea Crustacean Managed Fishery; and
- West Coast Rock Lobster Fishery.

There are no aquaculture operations within 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

No tourist activities take place specifically within the Operational Area; 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).

Shipping

The NWMR supports significant commercial shipping activity, the majority of which is associated with the mining and oil and gas industries. The Australian Maritime Safety Authority (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. One fairway overlaps the Operational Area (GWF-2 and EY pipelines) west of the GWA facility platform (Figure 4-1).

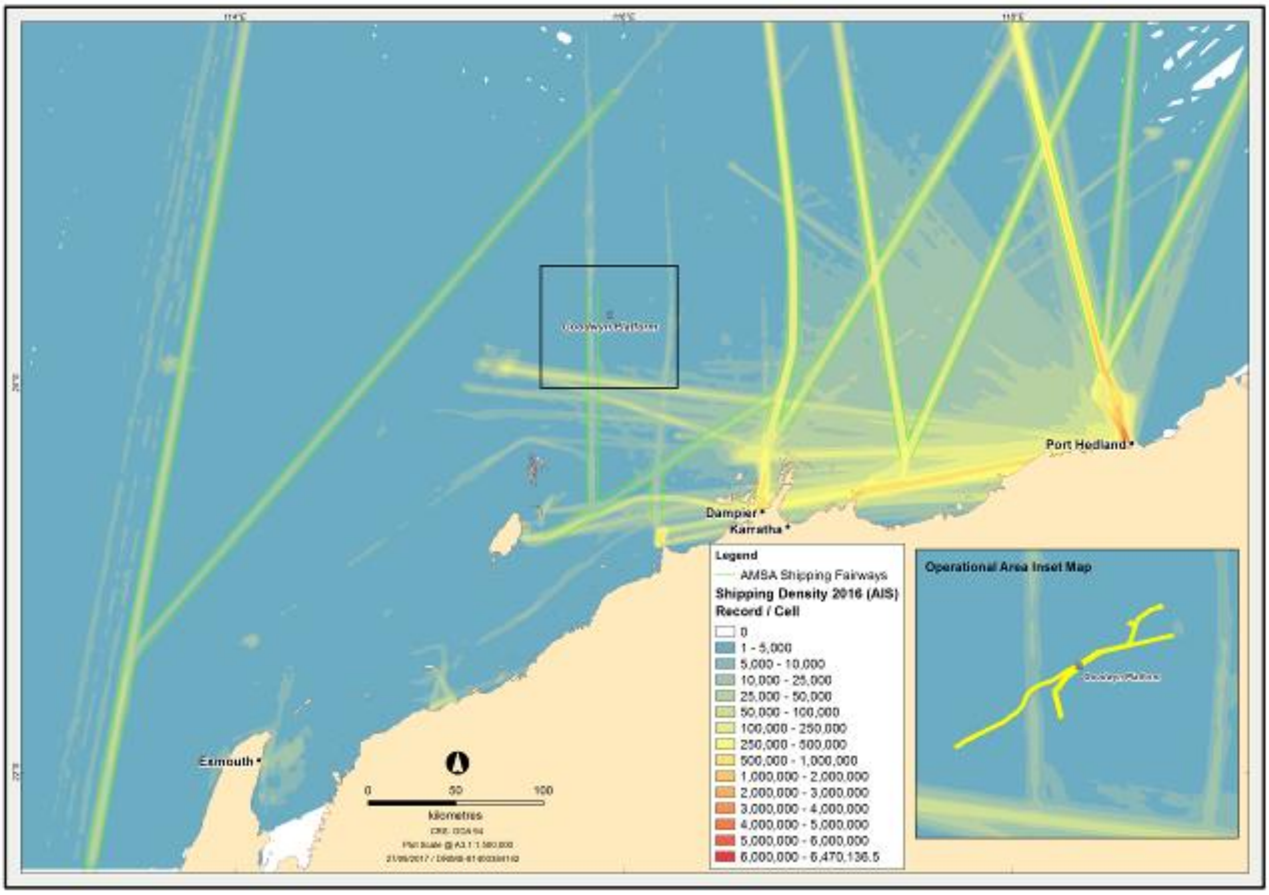

Figure 4-1: Vessel density map in the vicinity of Operational Area from 2016, derived from AMSA satellite tracking system data (vessels include cargo, LNG tanker, passenger, support and other vessels)

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 facilities [floating production storage and offloading (FPSOs) and platforms] 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, beyond the Operational Area. A Royal Australian Air Force base located at Learmonth, on North West Cape, lies approximately 312 km south-west 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.

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

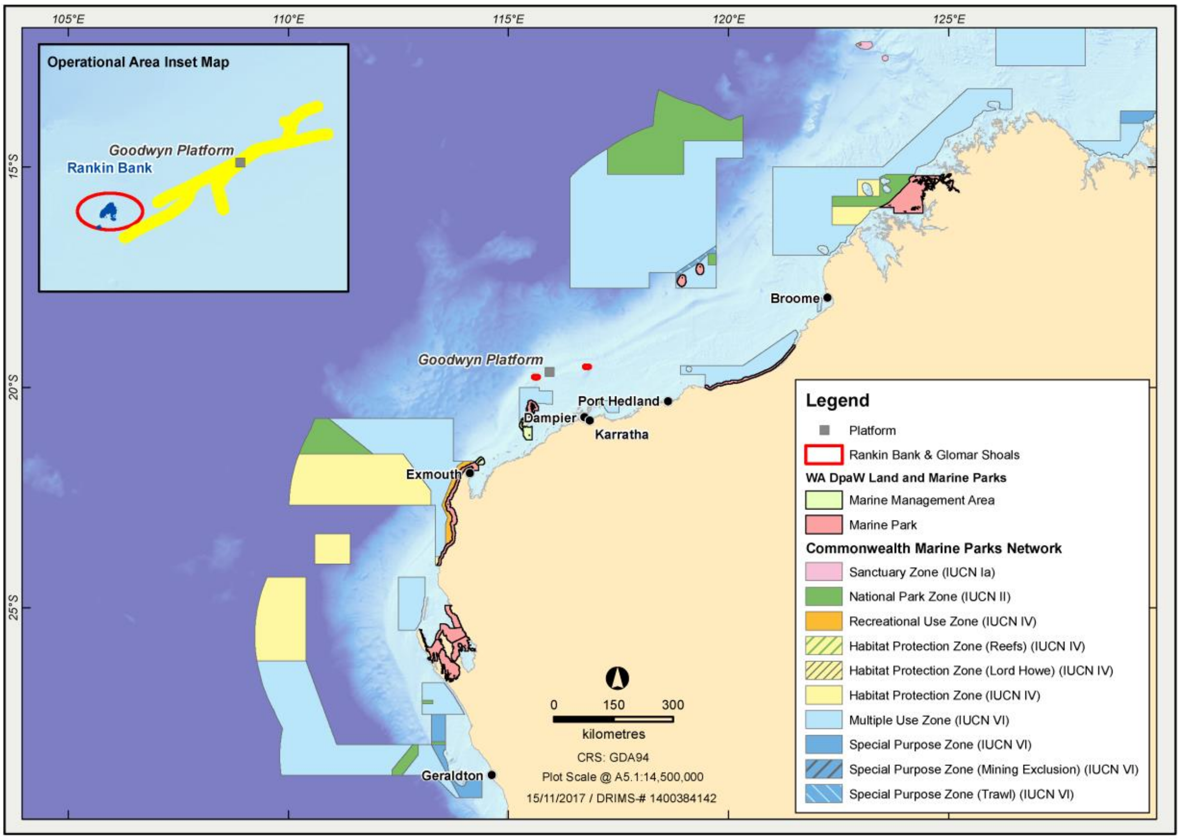

Figure 4-2: Commonwealth and State Marine Protected Areas in Relation to the Operational Area

Table 4-2: Summary of Established and Proposed Marine Protected Areas (MPAs) 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*
Commonwealth Marine Parks		
Montebello	17	VI
Dampier	106	II and IV
Argo-Rowley Terrace	197	II and VI
Gascoyne	220	II, IV and VI
Ningaloo	251	II
Mermaid Reef	355	IA
Shark Bay	560	VI
Abrolhos	790	II and VI
State Marine Parks and Nature Reserves		
Marine Parks		
Montebello Islands	52	IA, II, IV and VI
Barrow Island	103	IA, IV and VI
Ningaloo	252	IA, II and IV
Rowley Shoals	356	IA and II
Shark Bay	682	IA, II and IV
Marine Management Areas		
Barrow Island	70	IV and VI
Muiron Islands	233	IA and VI
Fish Habitat Protection Areas		
Point Quobba	564	IV
Nature Reserves		
Montebello Islands Conservation Park†	59	II
Montebello Islands Nature Reserve†	83	IA
Barrow Island Nature Reserve†	94	IA
World Heritage Areas		
Ningaloo	233	Not applicable
Shark Bay	592	Not applicable
Key Ecological Features		

	Distance from Operational Area to Values / Sensitivity boundaries (km)	International Union for the Conservation of Nature (IUCN) Protected Area Category*
Ancient Coastline at 125 m Depth Contour	Overlaps Operational Area	Not applicable
Continental Slope Demersal Fish Communities	25	Not applicable
Glomar Shoals	44	Not applicable
Exmouth Plateau	133	Not applicable
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	206	Not applicable
Commonwealth Waters Adjacent to Ningaloo Reef	251	Not applicable
Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals	345	Not applicable
Western Demersal Slope and Associated Fish Communities	719	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 – protect ecosystems and natural values, but facilitate human visitation*
- *IV: Habitat / species management area – conservation of a particular species, taxonomic group or habitat*
- *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 GWA facility and the control measures to manage the identified environmental impacts and risks to as low as reasonably practicable (ALARP) and an acceptable level. This risk assessment and evaluation was undertaken using Woodside's Risk Management Framework.

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

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

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

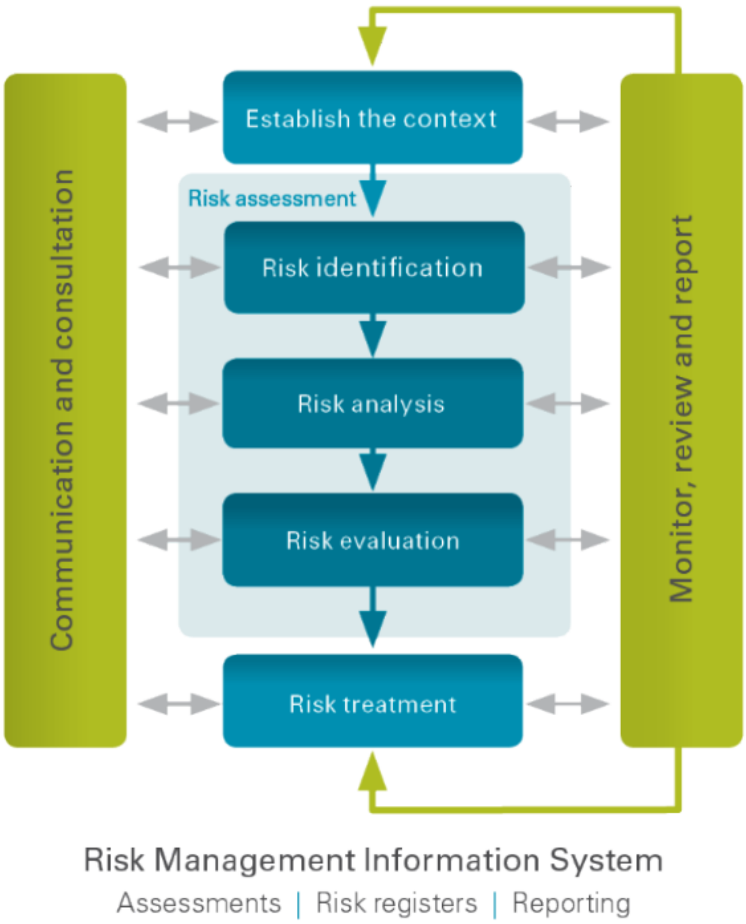

Figure 5-1: Key steps in Woodside's Risk Management Process

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.

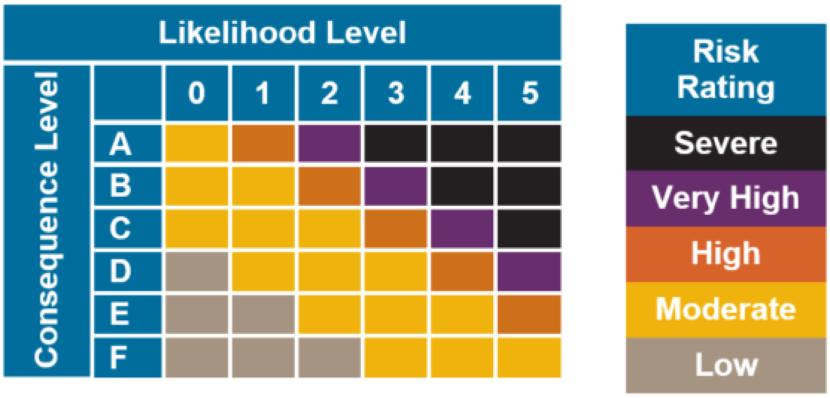

Figure 5-2: Woodside Risk Matrix: Risk Level

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 (MEEs). 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 (MSPS) 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[2].

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 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.

[2] *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

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

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

<table>
<tr><th>Risk</th><th>Impact</th><th>Decision Type</th></tr>
<tr><td>Low and Moderate (below C level consequence)</td><td>Negligible, Slight or Minor</td><td>A</td></tr>
<tr><td colspan="3">Woodside demonstrates these Risks, Impacts and Decision Types are '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.</td></tr>
<tr><td>High, Very High or Severe (C+ consequence risks)</td><td>Moderate and above</td><td>B and C</td></tr>
<tr><td colspan="3">Woodside demonstrates these higher order Risks, Impacts and Decision 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;</td></tr>
</table>

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

As the weathering of different fates of hydrocarbons (surface, accumulated, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, the locations potentially affected by each fate will differ.

The 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. Browse condensate is the closest hydrocarbon Woodside has ecotoxological testing data for, based on the similarity of the percentage of volatile and aromatic components to the hydrocarbons that may credibly be released during the Petroleum Activities Program (comparisons presented in **Table 5-7**). Note that all condensates considered in the modelling studies have a low asphaltene (< 0.1%) and wax (~0.2-0.9%) content. Based on this comparison, Browse condensate is considered to be a reasonable analogue for the basis of ecotoxological testing, confirming a dissolved hydrocarbon threshold.

Table 5-7: Comparison of the Hydrocarbon Types (See Appendix A)

Hydrocarbon Type	Initial Density (g/cm³ at 15°C)	Viscosity (cP @ 20˚C)	Component Boiling Point Percentage of Total				Aromatic (%) of whole oil <380°C BP
			Volatiles <180˚C	Semi volatiles 180–265˚C	Low Volatility (%) 265–380˚C	Residual (%) >380˚C	
			Non-Persistent			Persistent	
GWA facility Condensate	0.753	0.5118	71.6	19.8	7.0	1.6	13.2
GWF-1 Condensate	0.780	0.971	65.7	22.8	10.1	1.4	18.0
GWF-2 Condensate	0.737	0.820	52.6	28.8	15.9	2.7	9.1
Browse Condensate	0.780	1.092	57.0	21.0	8.0	14.0	15.75
Marine diesel	0.829	4.0	6	34.6	54.4	5	-

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

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

Biota and Life Stage	Exposure duration	NOEC – TRH concentration of unweathered Browse condensate showing no direct biological effect (ppb)
Sea urchin fertilisation	1 hour	3670 – 15,590
Sea urchin larval development	72 hours	8040 – 32,360
Rock oyster larval development	48 hours	15,820 – 32,360
Macro-algal germination	72 hours	39,490 – 77,310
Micro-algal growth test	72 hours	24,270 – 39,490
Larval fish imbalance test	96 hours	1280 - 3670
Tiger prawn acute toxicity test	96 hours	1280 - 2030

Source: ESA 2009

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

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

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

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

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

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

5.4.5 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.

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 that were assessed as not being applicable (not credible) within or outside the Wellhead Operational Area as a result of the Petroleum Activities Program. These sources of environmental risk / impact were determined to not form part of the EP and are described in the following sections for information only.

Shallow/Near-shore Activities

The Petroleum Activities Program is located in water depths of approximately between 77 and 131 m and at a distance approximately 59 km from nearest landfall (Montebello Islands), consequently risks / impacts associated with shallow / near-shore activities such as anchoring and vessel grounding were assessed as not credible. Rankin Bank, a relatively shallow feature in close proximity to the Operational Area (3.5 km from the Operational Area at the closest point and 30 km away from the GWA facility) will not credibly be impacted by shallow / near-shore activities.

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 GWA facility platform and subsea infrastructure excluding and/or displacing other users from Petroleum Safety Zone and Operational Area respectively.	Potential 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 GWA 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 minor, localised modification of seabed habitat within Operational Area.	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: • GWA facility and associated infrastructure; • Vessels; and • Helicopters.	Localised behavioural impacts to marine fauna around vessels and GWA facility platform.	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, short-term decrease in water quality around subsea system within Operational Area.	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.	F		Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of chemicals remaining in subsea pipeworks and equipment or the use of chemicals for subsea inspection, maintenance and repair (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
Routine and Non-Routine Discharges: Discharge of Produced Water	A	Discharge of Produced Water via a caisson during routine operations.	Potential minor, short-term impact to water quality, marine sediments and marine biota.	E		Environment – Slight short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly acceptable
		Discharge of Produced Water via caisson during unloading of wells for non-routine operations.	Potential minor, short-term impact to water quality, marine sediments and marine biota.	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 of sewage, putrescible waste, grey water,	A	Discharge of sewage, grey water and putrescible waste from vessels and GWA facility to the marine environment	Potential slight, short-term, localised ongoing increase in nutrients and oxygen demand around GWA facility platform and vessels.	F	Cumulative E	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable

bilge water, drain water, cooling water and brine		Discharge of deck, bilge and drain water from vessels and GWA facility to the marine environment.	Potential slight, short-term localised 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 reverse osmosis brine from vessels and GWA facility to the marine environment.	Negligible, localised increase in salinity at the discharge location.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Discharge of cooling water from vessels and GWA facility to the marine environment.	Potential slight, localised increase in water temperature, and short term water quality changes around discharge location.	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	GWA facility internal combustion engines, operational flaring and fugitive emissions, and vessel emissions (including incinerators).	Potential slight short-term, localised air quality changes, limited to the airshed 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 platform lighting, vessels operations and operational flaring	A	Light emissions from GWA facility platform and vessels.	Negligible, localised potential for behavioural disturbance of species in close proximity to GWA facility platform and vessels.	F	Environment – No lasting effect (< 1 month). Localised impact not significant to environmental receptors.	Broadly acceptable
		Light emissions from GWA facility platform during flaring.	Negligible, localised potential for behavioural disturbance of species in close proximity to GWA facility platform	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 release during bunkering/ refueling and chemical release during transfer storage and use	A	Accidental spill of hydrocarbons to the environment during bunkering / refueling.	Potential minor short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or temporary impacts to water quality.	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 environment from storage, use or transfer.	Potential slight, localised, short term impacts to marine water quality.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly 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 slight short term impacts to the marine fauna, and localised temporary impacts to water quality and marine sediments.	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.	E	Environment – Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	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	
Physical presence: Introduction of invasive marine species	A	Invasive species in vessel ballast tanks or on vessels / submersible equipment.	Potential introduction of invasive marine species possibly resulting in an alteration of the localised environment.	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	Release of hydrocarbons resulting from loss of platform well 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.	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
		Release of hydrocarbons resulting from loss of subsea well containment.		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	Release of hydrocarbons resulting from loss of containment of subsea flowlines and infrastructure (GWF-1, GWF-2, PoG).	Potential moderate short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	0	M	Acceptable if ALARP
		Release of hydrocarbons resulting from loss of export pipeline containment (IFL, including 2TL inventory)	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	0	M	Acceptable if ALARP
Unplanned hydrocarbon release: Topsides loss of containment (MEE-03)[3]	A	Hydrocarbon release from topside process equipment to the marine environment and atmosphere	Potential moderate short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (< 1 year) on ecosystems, species, habitat or physical or biological attributes	1	M	Acceptable if ALARP
		Hydrocarbon release from topsides non-process equipment to the marine environment	Potential minor short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or temporary impacts to water quality.	D	Environment – Minor short-term impact (1-2 years) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	3	M	Acceptable if ALARP
Unplanned hydrocarbon release: Loss of structural integrity (MEE-04)	A	Hydrocarbon release from platform well to the marine environment and atmosphere.	Potential significant impacts to the marine environment: Short to medium term impacts to the offshore marine	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

[3] MEE classification 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	
		Hydrocarbon release from pipeline and riser to the marine environment and atmosphere.	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	0	M	Acceptable if ALARP
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere.	Potential moderate short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	1	M	Acceptable if ALARP
		Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA.		C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	0	M	Acceptable if ALARP
Unplanned hydrocarbon release: Loss of marine vessel separation (MEE-05)	A	Hydrocarbon release from platform well to the marine environment and atmosphere	Potential significant impacts to the marine environment: Short to medium term impacts to the offshore 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 pipeline and riser to the marine environment and atmosphere		B	Environment – Major, long-term impact (10-50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	0	M	Acceptable if ALARP
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere	Potential moderate short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	1	M	Acceptable if ALARP
		Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA.		C	Environment – Major, long-term impact (10-50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	0	M	Acceptable if ALARP
Unplanned hydrocarbon release: Loss of suspended load (MEE-06)[4]	A	Hydrocarbon release from pipeline and riser to the marine environment and atmosphere	Potential moderate short term impacts to the marine environment: Including disruption to marine fauna, including protected species and/or impacts to water quality.	C	Environment – Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	1	M	Acceptable if ALARP

[4] MEE classification 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	
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere		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 GWA Facility Platform 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 GWA Facility Platform 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:

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

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

7.1 Environment Plan Revisions and Management of Change

Revision of the GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations) relating to hydrocarbon spill response arrangements.

- Oil Pollution Emergency Arrangements (OPEA) (Australia);
- The GWA Facility Operations First Strike Plan;
- Oil Spill Preparedness and Response Mitigation Assessment for GWA Facility Operations;
  - 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 MODU to drill intervention well via Memorandum of Understanding (MoU) with other industry participants;
- Master services agreement with Australian Marine Oil Spill Centre (AMOSC) for the supply of experienced personnel and equipment;
- 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 GWA 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 & 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 GWA Facility Operations Oil Pollution First Strike Plan

The GWA Facility Operations 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 platform and subsea support vessels will have Ship Oil Pollution Emergency Plans (SOPEPs) in accordance with the requirements of International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 Annex I. These plans outline responsibilities, specify procedures and identify resources available in the event of a hydrocarbon or chemical spill from vessel activities. The GWA Facility Operations 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 GWA Facility Operations 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. Woodside would implement the following operational monitoring plans to satisfy the requirements of this strategy. The following operational monitoring programs are available for implementation:
    - Predictive modelling of hydrocarbons to assess resources at risk;
    - Surveillance and reconnaissance to detect hydrocarbons and resources at risk;
    - Monitoring of hydrocarbon presence, properties, behaviour and weathering in water;
    - Pre-emptive assessment of sensitive receptors at risk; and
    - Monitoring of contaminated resources and the effectiveness of response and clean-up operations.
- 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.
- Wildlife response - An oiled wildlife response would be undertaken in accordance with Woodside's Health, Safety, Environment and Quality Policy and values and recognition of societal expectations.

The response would involve reconnaissance from vessels, aircraft and shoreline surveys, the capture, transport, rehabilitation and release of oiled wildlife.

- Scientific monitoring - A scientific monitoring program (SMP) would be activated following a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted ZoC and in particular, the identified Pre-emptive Baseline Areas (PBAs) in the event of a loss of well control from the PAP drilling activities (refer to response planning assumptions). The SMP would be informed by the operational monitoring programs, but differs from the operational monitoring program in being a long-term program independent of, and not directing, the operational oil spill response. Key objectives of the Woodside oil spill scientific monitoring program are:
  - Assess the extent, severity and persistence of the environmental impacts from the spill event; and
  - Monitor subsequent recovery of impacted key species, habitats and ecosystems.
- Waste management - Waste management is considered a support strategy to the response strategies examined above.

9. CONSULTATION

In support of the GWA Facility Platform 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 GWA Facility Platform 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 GWA Facility Platform 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
Department of the Environment and Energy	Administers the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
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 • Western Tuna and Billfish

Organisation	Relevance
Western Australian Fisheries	Commercial fisheries – State • Pilbara Demersal Scalefishery (Pilbara Trap and Trawl) • Marine Aquarium Managed Fishery • Specimen Shell Managed fishery • Onslow Prawn Managed fishery
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

Woodside continue to engage and consult with relevant stakeholders throughout the proposed 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.

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

9.1 Ongoing Consultation

Consultation activities for the Petroleum Activities Program build upon Woodside's extensive and ongoing stakeholder consultation for offshore petroleum activities in this area.

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.

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

9.2 Non-Routine Events

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

Stakeholder groups include:

- Government Ministers;
- Government agencies;

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

10. TITLEHOLDER NOMINATED LIAISON PERSON

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11. ABBREVIATIONS

Term	Description / Definition
2TL	Second Trunkline
AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
AMSA	Australian Maritime Safety Authority
AMOSC	Australian Marine Oil Spill Centre
APPEA	Australian Petroleum Production & Exploration Association
BIA	Biologically Important Area
BDV	Blowdown valves
CCR	Central Control Room
CSIRO	Commonwealth Scientific and Industrial Research Organisation
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
EY	Echo Yodel
FLC	Fluid loss control
FPSO	Floating Production, Storage and Offtake vessel
GWA	Goodwyn Alpha
GWF	Greater Western Flank
GWF-1	Greater Western Flank Phase 1
GWF-2	Greater Western Flank Phase 2
HP	High Pressure
ICS	Incident command structure
IUCN	International Union for the Conservation of Nature
IFL	Interfield line
KEF	Key Ecological Feature
KM	Kilometer
LAT	Lowest Astronomical Tide
LCM	Lost circulation material
LP	Low Pressure
LOC	Loss of containment

MAE	Major Accident Events
MARPOL	International Convention for the Prevention of Pollution from Ships
MEE	Major Environmental Events
MEG	Monoethylene Glycol
MoU	Memorandum of Understanding
MODU	Mobile Offshore Drilling Unit
MSPS	Management system performance standards
MPA	Marine Protected Areas
NOEC	No observed effect concentration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NRC	North Rankin Complex
NWMR	North-west Marine Region
NWS	North-west Shelf
OCNS	Offshore Chemical Notification Scheme
ODS	Ozone depleting substances
OIW	Oil in water
OPEA	Oil Pollution Emergency Arrangements (OPEA)
OWDS	Oily water drains separator
ppm	Parts per million
ppb	Parts per billion
PBA	Pre-emptive Baseline Area
PW	Produced Water
PLONOR	Pose Little or No. Risk to the Environment
RESDV	Riser Emergency Shutdown Valve
ROV	Remote Operated Vehicle
SCM	Subsea Control Modules
SDU	Subsea Distribution Units
SOPEP	Ship Oil Pollution Emergency Plan
SSIV	Sub-sea isolation valve
SSSV	Sub-surface safety valves
SCE	Safety Critical Elements
SMP	Scientific monitoring program
TEG	Triethlene Glycol
TPH	Total Petroleum Hydrocarbons
UK	United Kingdom
UTA	Umbilical Termination Assemblies
UTB	Umbilical Termination Baskets

VES	Valve and equipment skid
WA	Western Australia
WA DMP	Department of Mines and Petroleum WA DMP
WAF	Water accommodated fractions
WAFIC	Western Australian Fishing Industry Council
WOMP	Well Operations Management Plan
Woodside	Woodside Burrup Pty Ltd (note references to Woodside may also be references to Woodside Petroleum Ltd or its applicable subsidiaries)
ZOC	Zone of Consequence

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APPENDIX A: ENVIRONMENTAL IMPACTS AND RISKS

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 GWA facility platform and subsea infrastructure excluding and/or displacing other users from Petroleum Safety Zone and Operational Area respectively.							X	B	F	-	-	LC GP PJ S	Broadly acceptable

Description of Source of Impact

The GWA facility commenced operation in 1995 and has been marked on nautical charts since that time. The GWA facility is surrounded by a 500 m radius petroleum safety zone; which vessels are prohibited from entering unless authorised by Woodside. The petroleum safety zone is a critical safety control intended to reduce the likelihood of interactions between vessels and the platform, which increases safety for both vessels and the GWA facility. Implementation of the petroleum safety zone excludes other users from a small area of the sea (approximately 0.079 km^2). The GWA facility platform is highly visible under most conditions and is well lit, and the nature of the GWA facility (large steel structure) ensures a clear radar return to alert ships fitted with anti-collision radars.

Routine vessel activities associated with the Petroleum Activities Program are concentrated within the petroleum safety zone (e.g. platform support vessels at the GWA facility). 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: A number of commercial fisheries overlap the Operational Area. Commercial fishing vessels in the vicinity of the Operational Area are most likely to be participants of the Pilbara demersal scalefish fishery, and may employ several gear types (primarily trawling). The majority of the Operational Area (including the GWA facility) lies within an area that is permanently closed to trawl fishing, with only the IFL and the PoG field and pipeline within the area that may be trawled of Zone 2 of the fishery. This region of the Operational Area is approximately 90 km^2, or less than 0.4% of the total Zone 2 area (approximately 24,580 km^2) available for trawling. As such, impacts from the physical presence of the GWA facility and subsea infrastructure are expected to be confined to localised displacement of fishing effort from the Operational Area.

Tourism and Recreation: Tourism and recreation activity in the Operational Area is expected to be infrequent, with recreational and charter fishing from vessels the only tourism and recreation activities identified as potentially occurring in the Operational Area. Consultation outcomes did not indicate any recreational fishing occurs within the Operational Area. Any recreational and charter fishing from vessels is largely undertaken using lines. Given the distance from boating facilities, lack of natural attractions and water depth of the Operational Area, very little recreational or charter fishing is expected to occur. As such, impacts to recreational and charter fishing are expected to be localised and of no lasting effect. Some recreational fishing may occur at Rankin Bank, which lies in close proximity to the Operational Area (3.5 km from the Operational Area at the closest point).

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

- Bulk carriers (e.g. mineral ore, salt etc.) from Port Hedland and Dampier;
- Offtake tankers;
- Support vessels for offshore oil and gas activities; and
- LNG carriers from Dampier, Barrow Island and Ashburton North.

To reduce the likelihood of interactions between commercial vessels and offshore facilities, AMSA have introduced a series of shipping fairways, within which commercial vessels are advised to navigate. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. The fairway intended to direct north/south-bound vessel traffic from Barrow Island and the southern Montebello Islands overlaps the Operational Area and lies within DOA (GWF-2) subsea infrastructure. The use of shipping fairways is considered to be good seafaring practice, with AUSREP data from AMSA indicating cargo ships and tankers routinely navigate within the established fairways. Operational history of the GWA facility indicates that commercial vessels entering the petroleum safety zone very rarely.

The presence of the GWA facility platform, vessels and subsea infrastructure 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.

Oil and Gas: The nearest other oil and gas platform is the NRC, which is tied to the GWA facility by the IFL. NRC is operated by Woodside; impacts from the Petroleum Activities Program to NRC will not affect third parties. The nearest facility not operated by Woodside is the Chevron-operated Wheatstone platform, which lies approximately 30 km west of the Operational Area. Given the distance between the Operational Area and petroleum activities undertaken by other operators, no impacts to other operators will occur as a result of the presence of the GWA facility platform, vessels or subsea infrastructure.

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 GWA facility platform;
- Notify Australian Hydrographic Service of location of new permanent GWA 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;
- Other vessels aware of the presence of the GWA facility. Integrity will be managed in accordance with SCE Management Procedure and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs
    - 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 GWA facility and subsea infrastructure 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 activities including:

- Physical presence of the GWA facility and subsea infrastructure;
- Scour, spans, and flowline movement inherent in design; and
- Subsea IMR activities.

Subsea infrastructure occurs throughout the Operational Area. The installation of subsea equipment has been installed historically subject to separate Environment Plans. Installation and historical operations have described the benthic footprint/disturbance. Existing subsea infrastructure physical footprint is described in this section for completeness.

The GWA facility also provides hard substrate habitat from the sea surface through the water column to the seabed (e.g. jackets and risers), as well as along the seabed (e.g. pipelines, flowlines, manifolds etc.).

The presence of subsea infrastructure may result in localised scouring around the infrastructure due to currents, subsurface waves, and seabed sediment fluid dynamics. Operational experience indicates scour around subsea infrastructure associated with the Petroleum Activities Program is localised with negligible impact to environmental receptors. Scour around subsea infrastructure may necessitate IMR activities as part of integrity management practices.

Flowline movement may occur as per design and within integrity margins along the flowline corridor. Normal flowline operational movement occurs due to factors such as flowline buckling, walking and varying metocean conditions. Lateral movement can occur within the flowline corridor. Management of flowline buckling, and walking may necessitate IMR activities.

Refer to MEE-02 Pipeline and Riser Loss of Containment which includes controls to limit scour and flowline movement within integrity requirements. In order to maintain the integrity of subsea infrastructure, Woodside may be required to undertake routine subsea IMR activities, as described in. Activities that constitute IMR may impact upon the benthic environment in the vicinity of the activity. IMR activities identified as impacting the benthic environment include (but not limited to):

- 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, pipeline protection and stabilisation – minor, localised modification of benthic habitat within 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 are considered to be 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 on the

North West Shelf indicates these activities are typically restricted to relatively short (tens of meters) linear sections of pipeline, with areas of up to approximately 100 m^2 impacted.

Impact Assessment

Scour may result in localised impact to soft sediment benthic habitats, typically on the scales of meters to tens of meters. Soft sediment benthic habitats are very widely represented in the Operational Area and NWS Province more broadly. Impacts to the environment from scour around subsea infrastructure are expected to be localised, with no significant impact to benthic habitats in the Operational Area.

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 and Sediment 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 (described above). Each discrete IMR activity near the seabed is likely to cause a single brief disturbance resulting 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 fauna). Given the expected nature and scale of resuspension resulting from IMR activities, impacts such as smothering or burial are not expected. Rather, impacts are likely to be restricted to increased ingestion of inedible sediments by filter feeders. Biota in the region are well adapted to periodic turbidity events caused by cyclones and tidal movements. As such, impacts from turbidity caused by IMR activities are not expected to have any lasting effect on benthic biota.

Benthic Habitats

The benthic habitat within the Operational Area is predominately soft sediment with sparsely associated epifauna, which is broadly represented throughout the NWS Province North West Shelf. 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). The infauna communities are representative of the NWS province being of low abundance and dominated by polychaetes and crustaceans (RPS Environment and Planning 2012a).

Direct seabed disturbance, including permanent modification of benthic communities, may result as a consequence of IMR activities such as span rectification, pipeline protection and stabilisation. These activities will typically disturb a small area (typically < 100 m^2) of soft sediment habitat, which is broadly represented in the Operational Area and wider NWS region. This habitat will be replaced by hard substrate (e.g. concrete mattresses, rocks etc.), which is generally uncommon in the middle and outer NWS region. Over time, this hard substrate is expected to be colonised by sessile benthic biota (e.g. sponges, gorgonians etc.), which may support higher biodiversity than soft sediment habitats. 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 NWS province.

Filter Feeders (including outcropping cemented sediments with epifauna)

Filter feeder habitat has been widely observed in surveyed benthic habitats in the Operational Area, hosting low to moderate densities of filter feeding organisms. Additionally, subsea infrastructure such as pipelines can host sessile filter feeding communities comprised of organisms such as sponges; these communities support relatively diverse demersal fish assemblages (McLean et al. 2017).

As outlined above in “Other Benthic Communities”, IMR activities may result in minor loss of filter feeder habitat as a result of seabed disturbance. Although impacts to filter feeding communities resulting from IMR activities may result in permanent loss, this is expected to be restricted to a small portion of filter feeder habitat as represented in the wider NWS Province. Where the IMR activity creates hard substrate habitat (e.g. span rectification, pipeline protection and stabilisation), this habitat creation is expected to offset any filter feeder habitat loss. As such, impacts to filter feeders due to IMR activities are expected to be localised and not significant.

Values and Sensitivities

Ancient Coastline at 125 m depth contour

The Operational Area overlaps approximately 247.2 km^2 of the 16,189.8 km^2 Ancient Coastline, which is approximately 1.5% of the KEF. The Operational Area represents a 1500 m^2 buffer around the GWA facility subsea infrastructure to facilitate vessel operations; the potential for seabed disturbance is much more localised (i.e. within 10’s of metres is the subsea infrastructure).

Benthic habitat surveys in the region (including within the Ancient Coastline at 125 m depth contour KEF) indicate that benthic habitats within the KEF are characterized by sand interspersed with areas of rubble and outcroppings of limestone pavement (AIMS 2014b, RPS 2011). Such habitats are widely distributed in the NWS Province. No significant escarpments, species of conservation significance, emergent features or areas of high biological productivity characteristically associated with the Ancient coastline at 125 m KEF have been observed in the Operational Area. These impacts are discussed in relation to filter feeders above. The geomorphic feature the KEF is associated with is represented worldwide and represents the coastline during a previous glacial period. The geomorphic feature the KEF is associated with is represented worldwide and represents the coastline during a previous glacial period. Therefore, potential impacts to this regional-scale KEF are expected to be negligible.

Rankin Bank

Given the distance of Rankin Bank from the Operational Area (approximately 3.5 km at the closest point and approximately 30 km away from the GWA facility platform), the majority of resuspended sediments from IMR activities are expected to remain localised (i.e. deposited prior to reaching Rankin Bank). The NWS region experiences naturally high episodic sediment resuspension due events such as tidal movements and cyclones, and the biota in the region are adapted to such conditions. Additionally, environmental surveys of Rankin Bank (AIMS 2014a) did not indicate that the biota at Rankin Bank was subject to turbidity arising from the operation of the GWA facility and associated subsea infrastructure. As such, no impacts to the environmental sensitivities at Rankin Bank are expected to occur due to seabed disturbance during the Petroleum Activities Program.

Artificial Habitat

The presence of the GWA facility platform and subsea infrastructure provides hard substrate for the settlement of marine organisms; the availability of hard substrate is often a limiting factor in benthic communities. As such, the presence of the GWA facility and subsea infrastructure has led to the development of ecological communities which would not have existed otherwise. For example, pipeline infrastructure has been shown to support more diverse fish assemblages and benthic biota (McLean et al. 2017). These communities are relatively diverse compared to the open water and soft sediment habitats in the broader Operational Area, although the relatively high diversity of Rankin Bank (approximately 3.5 km west of the Operational Area at the closest point) is noted; refer to for additional information on Rankin Bank.

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

Summary of Control Measures

- Anchoring in the GWA facility petroleum safety zone will be prohibited except in emergency situations or under issuing of a specific permit;
- 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: • GWA facility and associated infrastructure • vessels; and • helicopters.						X		A	F	-	-	LCS GP PJ	Broadly acceptable

Description of Source of Impact

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

Vessels

Vessels may emit noise through the hull acting as a transducer (e.g. machinery vibration being converted to underwater noise), as well as through cavitation from fast moving surfaces such as propellers and thrusters. The main source of noise from vessels (both platform support and subsea support vessels) relates to the use of DP thrusters (i.e. cavitation from thruster propellers). The vessels undertaking the Petroleum Activities Program are expected to spend considerable time holding station during DP, which requires the use of thruster. Thruster noise (from cavitation caused by propellers) is typically the most significant noise source for vessels holding station, with other noise sources typically relatively minor (McCauley 1998).

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

All support vessels are required to comply with EPBC Regulation 2000 – Part 8 Interacting with Cetaceans to reduce the likelihood of collisions with cetaceans (refer to **Physical Presence: Vessel Collision with Marine Fauna**). Implementing this control may incidentally reduce the noise generated by vessels in proximity to cetaceans as vessels will be travelling slower; slower vessel speeds may reduce underwater noise from machinery noise (main engines) and propeller cavitation.

Helicopters

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Activities relevant to the Operational Area will relate to the landing and take-off of helicopters on the GWA facility (which occurs typically at 1-2 day intervals) and potentially subsea support vessels. During these critical stages of helicopter operations, safety takes precedence.

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

Wellhead, Pipelines and Subsea infrastructure

The noise produced by an operational wellhead was measured by McCauley (2002). 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 and 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 (2002), which included flow noise in pipelines, noise produced along a pipeline may be expected to be similar to that described for wellheads, with the radiated noise field falling to ambient levels within a hundred meters of the pipeline.

Woodside has undertaken acoustic measurements on the noise generated by the operation of choke valves associated with the Angel facility (JASCO 2015) similar to the design employed across GWA facility subsea valves. These measurements indicated choke valve noise is continuous, and the frequency and intensity of noise emitted is dependent 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 the majority of noise energy concentrated above 1 kHz. Noise from choke valve operation was considered minor compared to noise generated by vessels using thrusters in the area.

Platform Machinery

Production platforms have machinery mounted on decks raised above the sea, hence, most noise is transmitted to the marine environment from air. Machinery noise onboard the GWA facility platform may be radiated into the underwater environment via the jacket legs and risers, which may act as transducers. Underwater noise generated by the GWA facility is expected to be minimal, with monitoring programs indicating that underwater noise from platforms is typically very low or not detectable (McCauley 2002).

The HP and LP flare system will generate noise from combustion. Noise from flaring represents a health and safety risk to personnel, and noise from flaring was considered in the design of the GWA facility to manage the occupational health and safety risks associated with noise (e.g. height specification of flare tower). Noise from flaring is emitted at the top of the flare tower, which is approximately 175 m above sea level. Noise from the tip of the flare is not constrained and will spread spherically in all directions.

Subsea IMR Activities

Subsea IMR activities may result in localised, temporary increased in underwater noise. Given the nature and scale of expected IMR activities, noise generated during these activities is expected to be similar to, or less than, noise generated by subsea infrastructure during routine operations. No impulsive noise sources (e.g. piling, sub-bottom profiling etc.) will be used to undertake IMR activities.

Impact Assessment

Underwater Noise

The Operational Area of the Petroleum Activities Program is located in waters between approximately 77 and 131 m deep. The fauna associated with this area will be predominantly pelagic species of fish, with migratory species such as turtles, whale sharks and cetaceans present in the area seasonally. While the Ancient Coastline KEF may be associated with outcroppings of hard substrate, no evidence of significant reefs associated with such outcroppings has been found in the Operational Area. Note some demersal fish are likely to be associated with subsea infrastructure such as pipelines (McLean et al. 2017). Rankin Bank hosts marine fauna such as fishes and lies approximately 3.5 km from the Operational Area at the closest point.

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

(1) by causing direct physical effects on hearing or other organs, including:
  a. mortality / potential mortal injury resulting from exposure to noise;
  b. permanent threshold shift (PTS) – permanent reduction in the ability to perceive sound following exposure to noise; and
  c. temporary threshold shift (TTS) – temporary reduction in the ability to perceive sound following exposure to noise, with hearing returning to normal.

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

(3) 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 12-1** were considered in relation to the credible sources of acoustic emissions.

Table 12-1: 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 µPa^{2}s M-weighted SEL	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s M-weighted SEL	-	120-160 dB re 1 µPa rms SPL
Mid-frequency cetaceans*	198 db re 1 µPa^{2}s M-weighted SEL	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s M-weighted SEL	-	90-170 dB re 1 µPa rms SPL
High-frequency cetaceans*	179 db re 1 µPa^{2}s M-weighted SEL	198 db re 1 µPa^{2}s M-weighted SEL	183 db re 1 µPa^{2}s 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 12-1**, the potential for noise-induced mortality of cetaceans, fish, sea turtles and eggs / larvae is not considered credible. However, other impacts such as PTS, TTS, masking and behavioural impacts may occur. Using a simple cylindrical geometric spreading equation[5] to estimate transmission loss (TL) of thruster noise at 182 dB re 1 µPa at 100 Hz (**Table 12-2**), 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

[5] $TL = 20\log_{10}(R) + \alpha R$ where:

TL is transmission loss (in dB), R is the range between source and receptor, and α is the frequency-specific absorption coefficient (0.001 at 100 Hz) (Fisher and Simmons 1977) for typical seawater on the North West Shelf (temperate 25 °C, salinity of 35 PSU and pH of 8).

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 12-2** 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 12-2: 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

Given the migration corridor BIAs for pygmy blue whale (approximately 27 km from Operational Area at closest point) and humpback whales (approximately 23 km from Operational Area at closest point) lie beyond the range at which behavioural disturbances are expected to occur, no significant impacts (e.g. PTS, TTS) to these species are expected to occur during their seasonal migrations through the region. Behavioural impacts would be restricted to a small number of animals in relatively close (< 1 km) proximity to vessels.

Mid- and high frequency cetaceans 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.

Fishes

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, would be expected to behave normally once the noise emissions ceased. Note that a foraging BIA for whale sharks overlaps the Operational Area, and the 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, and they do not have a swim bladder (considered to increase the vulnerability of a fish to noise related impacts). 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. Fish at Rankin Bank (approximately 3.5 km from the Operational Area and approximately 30 km away from the GWA facility platform) are unlikely to be exposed to noise levels resulting in behavioural impacts. No impacts to fish associated with the Continental Slope Demersal Fish Communities KEF will occur due to the distance from the Operational Area (approximately 25 km at the closest point).

Turtles

Turtles may occur in the Operational Area (including an internesting BIA for flatback turtles overlapping 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. Turtles may forage at Rankin Bank; given the distance of Rankin Bank (approximately 3.5 km from the Operational Area at the closest point and approximately 30 km away from the GWA facility platform) received noise levels above impact thresholds is considered very unlikely to occur (**Table 12-2**).

Helicopter Noise

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

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 to be credible.

Wellheads, Pipelines and Platform Machinery Noise

Given the low levels of noise emitted by subsea infrastructure such as wellheads, choke valves, pipelines and the platform jacket legs, 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.

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 GWA facility platform 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.

Subsea IMR Activities

Given the nature and scale of typical IMR activities, underwater noise emissions from such activities are expected to be infrequent, of short duration. Underwater noise from IMR activities is expected to be similar to noise generated from routine operation of subsea infrastructure. Note that subsea support vessels will generate vessel-related noise. Refer to the assessment above for information on vessel-related noise impacts.

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 metres 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	F	-	-		
Discharge of chemicals remaining in subsea pipeworks and equipment or the use of chemicals for subsea inspection, maintenance and repair (IMR) activities.		X	X		X			A	F	-	-		

Description of Source of Impact

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

Operational discharge of control fluids 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; and
- Potential non-routine hydraulic fluid discharge associated with umbilical system losses/weeps.

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 pigging).

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).

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. A typical release associated with spool replacement may be approximately 15 L of hydrocarbon. IMR activities may also result in small gas releases associated with isolation testing and breaking into containment. Risk management processes are applied during activity planning to control IMR activity potential impacts and demonstrate ALARP through the use of techniques such as flushing. This process also includes an assessment to ensure the activity is undertaken in compliance with this EP.

Chemicals

Chemicals may be introduced into subsea infrastructure and production stream, either as process or non-process chemicals (e.g. corrosion inhibitors, biocides, scale inhibitors etc.). Chemicals flow through the production process, with residual chemicals discharged as a component of the PW via the hazardous closed drains caisson.

Chemicals may also 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.

The use of operational chemicals is restricted to that 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 described in **Section 3.8.2**.

Impact Assessment

There is potential for localised water column pollution 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 minor and are minimised as far as practicable via flushing off the lines back to the facility. Discharge locations are either the PW stream, subsea valves (subsea control fluid) or at disconnection points in subsea infrastructure.

Subsea Control Fluids

Subsea control fluids are selected in conformance with the chemical selection process outlined in **Section 3.8.2**. The subsea control fluid currently in use at the GWA 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. Subsea control fluids are discharged from subsea valves at or near the seabed in relatively small volumes. Visual inspections of subsea infrastructure observed epifauna communities on soft sediments in the Operational Area. 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 considered to be localised to the immediate vicinity of the release location with no lasting effect, based on:

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

Hydrocarbons

The small quantities of hydrocarbons that may be released during IMR activities that break containment of isolated subsea infrastructure will be buoyant and float upwards 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 dissolve within the water column. While recognising the potential ecotoxicity and physical effects of released hydrocarbons, the low release volumes, dispersion and dissolution is expected to result in hydrocarbon contamination decreasing to background levels rapidly. As such, impacts from routine and non-routine releases of hydrocarbons are assessed as being highly localised with no lasting effect.

For a discussion of hydrocarbons treated through the production process and discharged via the hazardous closed drains caisson, refer to the PW risk assessment.

Chemicals

The fate of chemicals introduced to the fluid processing stream may vary. Chemicals passed through the production process may become chemically or physically altered in response to changes such as pH, temperature or pressure. Chemical introduced into the production system may:

- become associated with the hydrocarbons that are exported from the GWA facility and be exported via the IFL (and hence are beyond the scope of this EP); and/ or
- become a component of the PW that is discharged via the hazardous closed drains caisson.

Refer to the PW risk assessment for an assessment of the impacts of chemicals discharged with PW.

Small quantities of chemicals such as inhibitor may also be released as a result of IMR activities such as disconnection and spool removal.

As outlined in the discussion of subsea releases are predominantly control fluid, and impacts from routine and non-routine discharges of chemicals will be localised to the immediate vicinity of the release location and not have lasting environmental effects, based on:

- the relatively small volumes of discharges;
- low residual chemical concentrations;
- the depth and low sensitivity of the receiving environment; and
- the 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 containing hydrocarbons flushed and appropriately isolated where practicable during IMR disconnection activities. • Monitor subsea control fluid use, investigate material discrepancies, and use control fluid with dye marker to support identification of potential integrity failures.

Routine and Non-Routine Discharges: Produced Water

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 PW from GWA facility platform.		X	X		X	X		B	E	-	-	LCS GP PJ RBA	Broadly Acceptable

Description of Source of Impact
Produced water (PW) is brought to the surface from the reservoir and is separated out from the hydrocarbon components during the production process and discharged to the marine environment. 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 etc.) and residual process chemicals. A description of the PW system has been provided in **Section 3.5.3**. Potential environmental impacts of PW discharge include changes in water quality, sediment quality and biota potentially reducing ecosystem integrity. In 2017, approximately 1,375 m^3/ day of produced water was discharged. PW rates are expected to increase as the field ages or new field be tied in. Future developments may introduce new reservoirs that produce water. The GWF-2 development is the only new tie back provided for under **Section 3**. The GWF-2 development ties in eight wells across six reservoirs, and Ready For Start Up (RFSU) is anticipated in H1 2019. The development proposes to tie-back all six reservoirs simultaneously. Water production from each reservoir is not expected to occur initially and it is difficult to anticipate with high confidence when wells will begin to produce water as they age. With the GWF-2 development, the predicted duration of PW discharge may extend up to 2030.

Monitoring and Management Framework

This section describes the monitoring and management framework for PW discharges which Woodside has developed to support the monitoring of PW discharges from offshore assets. In the absence of any Commonwealth guidelines, the State waters Technical Guidance: Protecting the quality of Western Australia's marine environment (EPA, 2016) has been considered and is consistent with the principles of the National Water Quality Management Strategy.

Environmental values are defined as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (ANZECC & ARMCANZ, 2000). The relevant environmental values considered are identified below:

- Ecosystem Integrity– maintaining ecosystem processes (primary production, food chains) and the quality of water, biota and sediment.
- Cultural and spiritual - In the absence of any specific environmental quality requirements for protection of this value it is assumed that if water quality is managed to protect ecosystem integrity this value is achieved in line with the guideline.

The relationship between key elements of ecosystem integrity, indicators and relevant monitoring activities undertaken on a routine and non-routine basis are shown in **Figure 12-1**. As per EPA guideline (2016) key elements to maintain ecosystem integrity have been identified as water quality, sediment quality and biological indicators (biota). By limiting the changes to these key elements to acceptable levels there is high confidence ecosystem integrity is maintained. For each of these elements an indicator has been identified and monitoring designed to identify changes. Monitoring changes in water quality and sediment quality as well as investigating potential toxicity via WET testing and implementing management to maintain acceptable levels of changes is standard industry practice in Commonwealth and State waters. The relevant indicators to understand changes in key elements and therefore potential for impact to ecosystem integrity are physio-chemical stressors; toxicants in water; biological indicators and toxicants in sediment. A number of trigger values for each indicator have been defined and are monitored to detect changes. Trigger values serve as an early warning that potential changes beyond the acceptable limits may occur. The acceptable limits of change are no impacts from PW beyond the approved mixing zone: To determine if acceptable limits have been exceeded routine monitoring of trigger values is undertaken. An approved mixing zone protects 99% of species, as calculated using the ANZECC/ARMCANZ (2000) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection and represents no detectable change from natural variation (as per ANZECC/ARMCANZ (2000)).

The approved mixing zone boundary for GWA facility is 1,200 m. The justification for this distance being "acceptable" is provided at the end of this section.

Operational Monitoring

OIW monitoring is undertaken via an online analyser or manual sampling when the analyser is not available. Online analyser information is sent via transmitter instantaneously and reported to the control system (DCS) and is also captured within the process historian database (PHD). The DCS facilitates visibility in the control room, for manual or automated process control changes to be made, and/or annunciate alarms (e.g. high oil in water specification). PHD information is available onshore for analysis and trending.

Any discrepancies that are identified between instrument readings and DCS/PHD that are outside of expected tolerance are investigated to determine the cause. Typically, discrepancies may be due to incorrect data logic in an automated calculation within PHD/DCS, which may be corrected through coding. Alternatively, discrepancies may be due to technical faults in the transmission of the data from the instrument (or a fault with the instrument itself), which may be addressed by corrective maintenance.

The results of manual sampling while the analyser is not available, are stored in a spreadsheet contained on the facility server. The results of each facility are consolidated by HSEQ on a monthly basis and internally reported. Any EPS breaches are noted as Recordable Incidents.

There may be periods of time where the online OIW analyser is not available. Please refer to the Controls Summary, below, for the frequency of manual sampling while no OIW analyser is available.

Routine Monitoring

PW is monitored and managed in accordance with the Offshore Marine Discharges Adaptive Management Plan (OMDAMP) [6].. The OMDAMP details trigger values, routine monitoring assessment against trigger values, analytical methods and actions when a trigger value is exceeded.

[6] *The OMDAMP is reviewed annually as such it is important to note the OMDAMP information presented in this EP is subject to change. Any changes in the OMDAMP are subject to the Change Management requirements in Section 6.1.4. In the event of any differences between this EP and the OMDAMP, the OMDAMP will be the authoritative document, provided the OMDAMP does not conflict with the Environmental Performance Standards of this EP.*

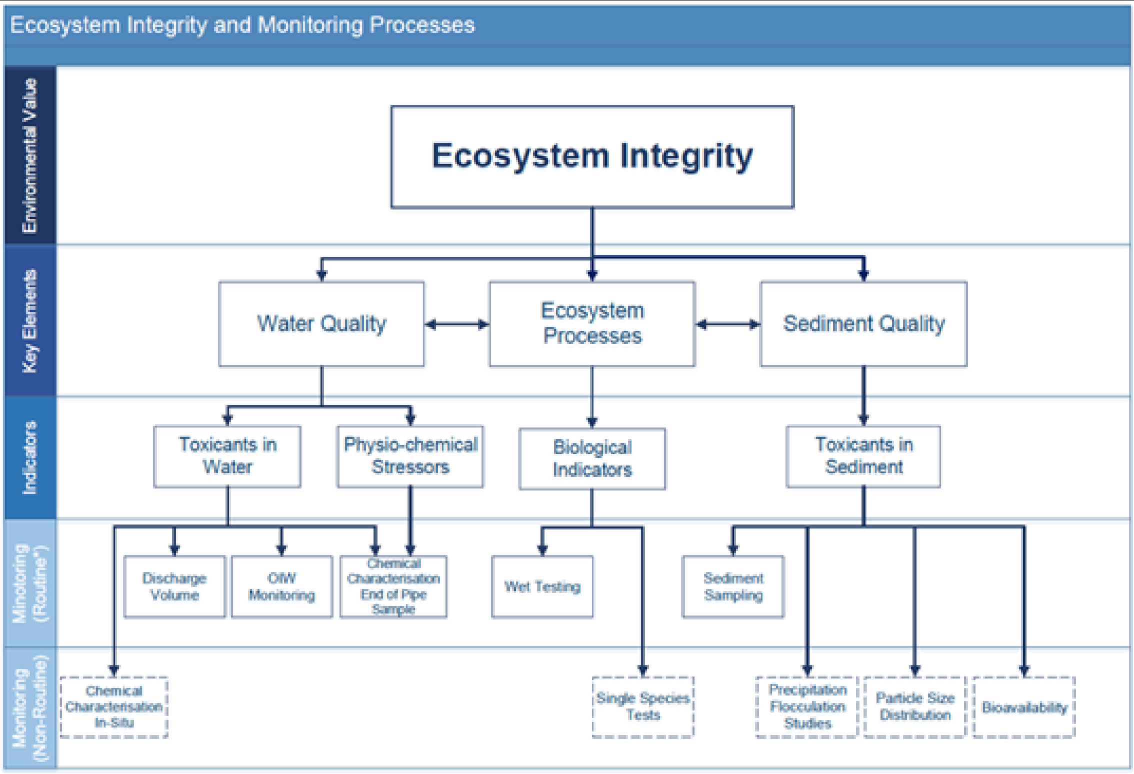

Figure 12-1: Ecosystem Integrity and Monitoring Process

The trigger values are applied through a risk-based approach that is intended to capture any uncertainty around the level of impact by staging monitoring and management responses according to the degree of risk to ecosystem integrity. The approach provides a level of confidence that management responses are not triggered too early (i.e. when there is no actual impact) or too late after significant or irreversible damage to the surrounding ecosystem" (EPA 2016). Routine monitoring is undertaken to compare against trigger values (described in **Table 12-3**). Unacceptable changes in water quality or sediment quality and raw PW toxicity are able to be detected early and can indicate the potential for an impact prior to an impact occurring. WET testing confirms if there is a potential for impact on biota. It is not appropriate to monitor for changes in species composition, diversity etc. as there are limited receptors in the direct impact zone (a surface buoyant plume) and such changes may be detected after an impact occurs and therefore are not considered appropriate for early detection. The WET tests are undertaken on a broad range of taxa of ecological relevance for which accepted standard test protocols are well-established. WET tests are mainly focused on the early life stages of test organisms, when organisms are typically at their most sensitive to contaminants are designed to represent local trophic level receptors. The dilutions required to protect 99% of species, is calculated using the ANZECC/ARMCANZ (2000) statistical distribution methodology on the results of direct toxicity assessment using sub-lethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection at the boundary of the approved mixing zone.

Table 12-3: Trigger Values Used During Routine Monitoring

Routine Monitoring	Trigger Value	Frequency
Chemical characterisation End of pipe sample - toxicants	Results that are predicted to be higher than the 99% species protection trigger value at approved mixing zone boundary and are above the results from the earlier toxicity year or above the toxicity year when no trigger was available.	Annual – timed to consider when new reservoirs cut water
Chemical characterisation End of pipe sample - physio chemical	Results that are predicted to be higher than the 99% species protection trigger value at approved mixing zone boundary and are above the results from the earlier toxicity year or above the toxicity year when no trigger was available.	Annual
	Increase in total suspended solids (TSS) exceeds parameters described in existing sedimentation studies.	Annual
WET testing	The safe dilutions derived from the WET testing species sensitivity distributions are not predicted to be achieved at boundary of approved mixing zone and are higher than previous years.	Three yearly. Conducted in parallel with annual chemical

		characterisation where feasible.
Sediment sampling	Results that are higher than the ISQG low trigger guideline values at boundary of approved mixing zone.[7]	Due in 2021 (Six yearly). Conducted in parallel with WET testing where feasible.
Review of continuous operational monitoring results	Increases in the average monthly OIW concentration by 5 mg/L for more than six consecutive months or by 10 mg/L for two consecutive months	Monthly
Discharge volume	Mean daily discharge volume exceeds modelled discharge at which approved mixing zone is met.	Monthly review

Note: earlier toxicity year means the year in which the most recent WET test occurred.

If a trigger value is met it triggers uncertainty around whether the environmental value is being protected and further investigation is required (**Figure 12-2**).

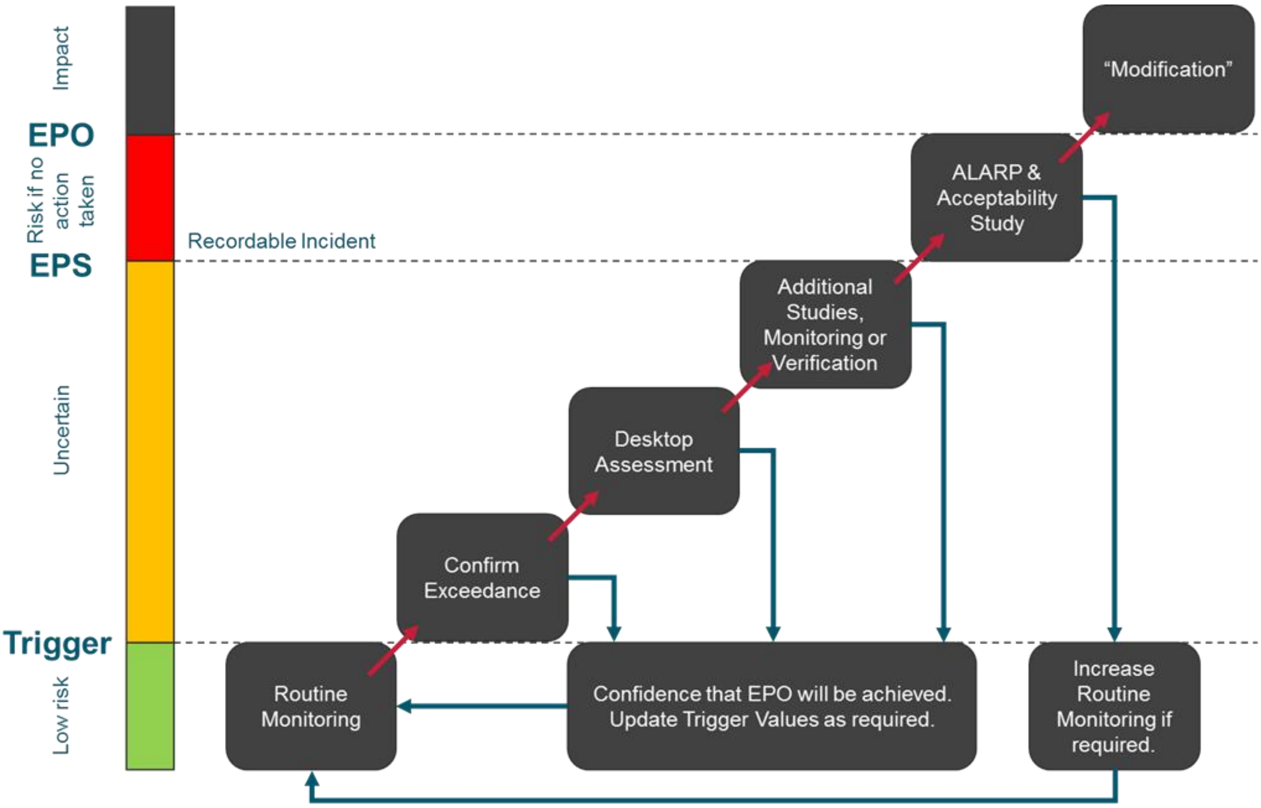

Figure 12-2: Routine Monitoring and Adaptive Management Framework for Produced Water

Further Investigations

Detectable exceedances in trigger values may occur without impacting ecosystem integrity. In order to provide confidence that ecosystem integrity has been achieved, further investigation in the form of a desktop study to initially assess the exceedance in context of available data (multiple lines of evidence) and confirm if there is potential for impact to the environmental value. A desktop assessment necessary before undertaking any additional infield monitoring. This ensures monitoring programs are designed and implemented to provide robust findings based on good survey design.

A range of methods can be used to detect trigger value exceedances (e.g. relative percentage difference, control charts, multivariate analysis etc., depending on the data set available. An appropriate method is selected as described

[7] where no guidelines are specified for a contaminant of interest, an interim approach shall be implemented as described in the ANZECC guidelines.

in the OMDAMP due to the variable nature of environmental data. If critical data is not available, the desktop study will identify potential data gaps and may recommend additional non-routine studies and/ or monitoring to ensure the assessment is appropriately undertaken. The purpose of the further investigations step is to provide certainty that the EPS) has been achieved, if a trigger value has been exceeded. The key investigation steps are described below:

1. Confirm the trigger value has been exceeded.

Review quality assurance and quality control, methodology and possible sources of contamination to determine if the results are reliable, or if any factors have occurred that may compromise the integrity of the monitoring or data.

2. Desktop assessment to understand whether the EPS is at risk.

If a trigger value is confirmed to be exceeded, multiple lines of evidence are considered including historical and current data from routine and non-routine monitoring and studies. This assessment shall consider whether there is adequate evidence to demonstrate that acceptability criteria have been met and ecological integrity is not at risk (EPS not breached). If the desktop assessment determines that the existing body of evidence is insufficient, it shall outline what additional monitoring or studies are required. Potential additional monitoring / studies may include but is not limited to the following:

- Single species test (collected annually in parallel with routine chemical characterisation should further investigation be required);
- Dilution modelling and or studies;
- Settling velocity analysis;
- Metal bioavailability;
- Scanning electron microscopy and particle size distribution analyses; and
- Chemical characterisation in-situ- water quality.

Routine monitoring activities may be required ahead of schedule and additional monitoring not listed may be undertaken as appropriate. Field monitoring (routine and non-routine) is undertaken in accordance with a plan that details timing, locations and objectives of monitoring.

3. Conduct additional studies to confirm the EPS is not at risk.

Monitoring results provide additional lines of evidence to determine whether there is a risk to ecosystem integrity due to unacceptable changes in water quality sediment, or biological indicators. Given the significant health, safety and technical risks, monitoring of the receiving environment is typically only considered when all other sources of evidence are insufficient to demonstrate that ecological integrity is not at risk. The OMDAMP provides detailed guidance on the steps and actions required to be undertaken if a trigger value is exceeded and this may include additional non-routine monitoring to verify that ecological integrity is maintained.

If environmental impact is deemed to be within acceptable limits of change the desktop assessment may consider a review of trigger values to ensure they are appropriate. If potential impacts to ecosystem integrity outside of the acceptable limits are identified, the EPS is breached and an ALARP/ Acceptability Study is required to determine what additional controls may be required to ensure the potential impacts are not realised. An EPS breach is a Recordable Incident.

ALARP/Acceptability Study

An ALARP/Acceptability study is conducted once it has been determined as a result of further investigations that there is potential for an impact which exceeds the acceptable limits of change.

The ALARP/Acceptability study shall be conducted in accordance with the ALARP Demonstration Procedure (Woodside Reference WM1040PF9258835), to determine additional controls that may be necessary to reduce the potential impacts. Additional controls may include technology or process upgrades, reservoir management. Woodside will implement the additional controls identified in the ALARP/Acceptability study which are required to give confidence that the acceptable limits on environmental impact can be achieved. Field validation of model assumptions and additional monitoring to assess whether impacts have been realised will be considered.

Impact Assessment

Potential impacts of PW discharge include:

- Changes to water quality;
- Toxicity to biota; and
- Changes to sediment quality.

In order to understand potential impacts from PW discharges, Woodside has undertaken a suite of comprehensive in-situ testing and sampling related to PW discharges representing long-term operational periods from its offshore production facilities. The details of this testing and resultant understanding of potential environmental impacts are outlined below.

Potential Impacts to Water Quality

Potential impacts to water quality have been assessed through chemical characterisation of PW and monitoring ongoing discharge volumes. Variability is managed via the Monitoring and Management Framework, which addresses variability associated with new water production from new reservoirs.

Chemical Characterisation of PW (Physio-chemical Parameters)

PW is discharged to the caisson and forms positively buoyant jets which rise towards the surface. As mixing increases and buoyancy of the plume erodes, the rise towards the surface slows. On reaching the surface the plume collapses and spreads horizontally whilst mixing vertically downwards. At approximately 40 m away from the discharge location the PW is diluted some 1000 times. At this point, far-field processes (ambient current and passive diffusion) control dispersion. Samples of undiluted PW sampled annually at the end of pipe from were analysed from 2011 to 2017 for key physio-chemical parameters (**Table 12-4**). The results were compared to the trigger values and if required further investigation was undertaken. In most cases results are below trigger values, or similar to the results of chemical characterisation in the previous year's WET testing was undertaken i.e. previous toxicity year (relative percentage difference).

It should be acknowledged that although exceedances of trigger values are highlighted in the tables below PW does not need to achieve 99% species protection at the end of pipe to meet the acceptable limits of change. No instances required confirmation that a significant change had not occurred with possible consequences to the toxicity of the PW and potential change to the extent of the mixing zone. In-situ monitoring conducted in 2015 could not detect the physical influence of the PW discharge stream in the water column to 50 m water depth at 20 m from the discharge location (BMT Oceanica 2015). Chemical characterisation of the undiluted PW indicated the TPH, PAH, BTEX and phenols were present at levels above to trigger value at end of pipe. However TPH, PAH, BTEX and phenols at all locations (i.e. >25 m from the GWA facility platform) and depths on the prevailing current in the receiving environment were below the 95% species protection trigger values and below laboratory LORs, (BMT Oceanica 2015)

Table 12-4: Physical and Organic Chemical Characterisation for GWA Facility (2011–2017). Values Exceeding ANZECC/ARMCANZ (2000) 99% Species Protection Guideline Values for Marine Water Shaded in Grey

Analyte		ANZECC trigger value [a]	2011	2014	2015	2016	2017
pH		-c	6.8	7.0	7.0	7.1	7.0
Salinity (PSU)		-c	16	21	21	21	20
Ammonia (NH3-N mg/L) pH adjusted		3.9	19	17	16	16	17
TSS (mg/L)		-c	-	14	4	3	4
Benzene, toluene, ethylbenzene and xylenes (BTEX) (mg/L)	Benzene	0.50 (mod)	4	3.8	7.2	4.3	3.9
	Toluene	f	4.1	4.5	8.5	5.1	4.8
	Ethylbenzene	f	0.12	0.21	0.38	0.2	0.19
	m and p-Xylene	f	0.74	1.7	2.6	1.8	1.5
	o-Xylene	f	0.39	0.61	0.92	0.61	0.54
	Xylenes	c	1.1	2.31	3.2	2.41	2.04
Total petroleum hydrocarbons (TPHs) (mg/L)	C6-C9	c	9.7	14	-	-	11
	C10-C14	c	7.5	20	-	6.1	7.6
	C15-C28	c	0.39	8.3	-	1.1	<0.1
	C29-C36	c	<0.1	0.17	-	<0.1	<0.1
National Environmental Protection Measure (NEPM) total recoverable hydrocarbons (TRHs) (mg/L)	C6-C10	c	-	15	22	12	11
	C6-C10 (no BTEX)	c	-	3.8	2	<0.25	<0.25
	>C10-C16	c	-	24	8.4	6.2	6.7
	>C10-C16 (no Naphthalene)	c	-	24	8.3	6.1	6.7
	>C16-C34	c	-	3.8	0.78	0.69	<0.1
	>C34-C40	c	-	0.14	<0.025	<0.1	<0.1
Polycyclic aromatic hydrocarbons (PAHs) (µg/L)	Naphthalene	50 (high)	99	170	120	120	150
	Acenaphthylene	c	<0.5	<0.5	<1	<0.5	<0.5
	Acenaphthene	c	<0.5	<0.5	<1	<0.5	<0.5
	Fluorene	c	1.1	1.3	1	0.65	0.64
	Phenathrene	f	0.98	2.5	<1	0.51	0.51
	Anthracene	f	-	-	<1	<0.5	<0.5
	Fluoranthene	f	-	-	<1	<0.5	<0.5
	Pyrene	c	-	-	<1	<0.5	<0.5
	Chrysene	c	-	-	<1	<0.5	<0.5

	Benzo(a)pyrene	f	-	-	<1	<0.5	<0.5
Phenols (mg/L)	Phenol	0.27 (high)	5.4	3.1	3.2	1.9	5.4
	2-Methylphenol	c	2.2	1.6	2.0	1.3	2.3
	3-and4-Methylphenol	c	3.1	2.1	3.1	1.7	3.1
	2,4-Dimethylphenol	f	1.4	0.63	1.8	2.2	0.75
Organic acids (mg/L)	Acetic Acid	c	538	560	400	360	350
	Butyric Acid	c	<1	16	9.9	11	12
	Isobutyric Acid	c	6.1	5.6	<5	<5	<5
	Propionic Acid	c	38.4	69	49	45	53

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

[c] No guideline value.

[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.

Nutrient concentrations in proximity to the PW discharge location were consistent with sites at a control distance from the discharge point (**Table 12-5**). These results are consistent with hydrocarbon, metals and physical properties monitoring, which in conjunction provide strong evidence that the PW discharge mixes rapidly and is not typically detectable within the water column beyond 100 m of the discharge location. Impacts from nutrients in the PW discharge are considered to be highly localised and pose negligible effects to environmental receptors.

Table 12-5: Measured Nutrient Parameters in the Receiving Environment

Parameter (µg/L)	Raw PW (2015 average)	Surface Water (0.5 m depth) at 100 m, 200 m and 5000 m from GWA Facility Platform in 2015		
		100 m	200 m	5000 m
Ammonia	16,000	<3	4	<3
Nitrate-nitrite	3.3	<2	<2	7.5
Total nitrogen	16,000	100	100	90
Total phosphorus	43	14	12	11.5
Filterable reactive phosphorus	32	2	1.5	<2

Physical and chemical changes to the PW as it becomes diluted following discharge may result in soluble chemicals precipitating out of solution, and becoming deposited to the sediment. Additionally, suspended particles may form aggregations (flocs), which may then settle out of the water column. The potential for toxicants to precipitate from PW was investigated in 2013, undiluted PW was analysed for filtered and total extractable metals, metal bioavailability, TSS and particle settling analysis (SKM, 2013a). Sedimentation analysis concluded that the PW had a very small amount of TSS, which did not change upon mixing with seawater and with no visible settling of particulates after the mixed sample was allowed to stand overnight. Furthermore, settling velocity analysis was attempted by the Microanalysis laboratory on the sample but no results were recorded because of the low concentration and small size of the particulates(SKM, 2013a). This suggests a low potential for toxicants in PW to precipitate and impact sediment quality.

In 2016, (Rob Phillips Consulting 2016) further investigations were undertaken to understand whether the discharge formed colloids and flocculates out of the water column. Undiluted PW was mixed with seawater with dilution there was very little precipitate formed supporting the findings of the earlier study. It is unlikely that flocculation of the PW is occurring in the receiving environment reducing risk of impacting the sediment quality. Based on historical monitoring and studies there has been little change in physio-chemical properties and the findings of previous studies are likely still pertinent.

Chemical Characterisation of PW (Toxicants in Water)

Samples of undiluted PW sampled annually at the end of pipe from were analysed from 2011 to 2017 for key toxicants (Table 12-6). The results were compared to the trigger values and if required further investigation was undertaken. In most cases values are below trigger values or similar to previous years WET testing was undertaken (relative percentage difference) It should be acknowledged that although exceedances of trigger values are highlighted in the tables below PW does not need to achieve 99% species trigger values at the end of pipe. Further investigation only identified one instance that required confirmation that a significant change had not occurred with possible consequences to the toxicity of the PW and potential change to the extent of the mixing zone. In 2016 total mercury concentrations increased in the undiluted sample. The concentrations of mercury were very small compared to the dilutions occurring once the PW is discharged to the marine environment and would take place within the current mixing zones (only 12 dilutions required). Therefore, a significant change had not occurred with possible consequences to the toxicity of the PW and potential change to the extent of the mixing zone.

Table 12-6: Metal and Metalloid Characterisation for GWA Facility (2011 – 2017). Values Exceeding ANZECC/ARMCANZ 99% Species Protection Levels for Marine Water Shaded in Grey.

Metal and Metalloid	ANZECC trigger value (µg/L) [a]	2011		2014		2015		2016		2017	
		Dissolved (µg/L)[b]	Total (µg/L)	Dissolved[b]	Total	Dissolved[b]	Total	Dissolved[b]	Total	Dissolved[b]	Total
Silver	0.8 (high)	<5	<5	<0.2	<0.2	<0.2	<0.2	0.02	0.11	<0.01	0.02
Aluminium	24[d]	-	-	<1	4	-	-	<1	3	<1	2
Arsenic	[f]	<0.3	2	-	-	1	1	-	-	0.26	0.27
Barium	[c]	24,600	25,100	32,800	30,200	33,000	37,000	32,000	33,000	35,300	34,700
Cadmium	0.7 (high)	<0.8	1.3	0.01	0.02	<0.2	<0.2	<0.003	<0.003	0.01	0.01
Chromium	8 (III) (moderate) 1.4 (V) (high)	-	-	0.07	0.07	<0.1	<0.1	0.16	0.14	<0.02	0.05
Cobalt	1 (high)	<1	1	<1	1	<0.4	2.1	1.3	2.1	1.46	2.78
Copper	0.3 (high)	<1	5	<0.1	<0.1	2.1	2.2	0.74	1	<0.2	<0.2
Iron	[c]	15	1,100	219	1,100	59	950	20	1,300	29	1,400
Manganese	140[e]	61	63	64	67	62	67	76	76	50	50
Nickel	7 (high)	<1	2	0.4	0.5	<0.6	1.7	0.8	0.7	0.79	0.87
Lead	2.2 (high)	<0.5	1	<0.1	<0.1	<0.2	<0.2	<0.04	0.32	<0.03	0.05
Zinc	7 (high)	<3	5	<1	3	10	10	<1	2	<1	<1
Mercury	0.1 (high)	-	1.64	-	1.34	<0.1	0.4	-	1.2	-	0.8

[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.

Insitu water quality sampling was conducted in February 2015 to coincide with the routine end of pipe sampling. Undiluted PW contained detectable levels of filtered barium, manganese, and zinc these diluted to below background concentrations in all receiving water samples (≥ 25 m from the discharge point). Copper was present in the undiluted PW and receiving environment (including at reference sites) (Jacobs, 2016).

Historical data indicates that toxicants from PW are rapidly diluted below ANZECC guidelines in the marine environment and is achieved well within the approved mixing zone. Continued annual chemical characterisation of the discharge stream is proposed to detect changes in water quality.

Discharge Volumes

The average volume of PW is currently discharged facility (1,375 m^3/day in 2017) which is expected to increase as the field ages up to the integrity limit. The maximum capacity referred to as the integrity limit is (7,500 m^3/day) has been modelled and is used to assess environmental impacts.

Changes in PW Composition

Initially when new wells are brought online no increase in routine PW volumes or changes in composition are anticipated. As the field age's wells may start to produce water. The proportion of PW to hydrocarbon and therefore volume of PW each well produces is expected to increase over the field life. To confirm whether there is potential to exceed the acceptable limit of change, routine annual chemical characterisation (toxicants and physio-chemical) are undertaken and assessed against trigger values. Chemical Characterisation is timed to provide a representative sample and where practicable, considers when new reservoirs begin producing water. Annual chemical characterisation may be delayed /advanced from the planned schedule or sampling in a subsequent period advanced if dictated by water-cut timing. This process would indicate any potential increase in toxicants and particulates in exceedance of the trigger values. Should trigger values be exceeded then further investigation is undertaken as outlined above. This provides confidence that the environmental impact is sustained within the approved mixing zone, in accordance with the goal of the management framework. A justification of why these impacts are ALARP and acceptable is presented at the end of this section.

Potential Impacts to Biota

Potential impacts of PW to Biological Indicators have been assessed through WET testing and dilution modelling to ensure that the approved mixing zone is achieved.

Wet Testing

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).

WET tests were undertaken to allow for interactions between toxicants and take into account toxicants which cannot readily be measured, or are not known to be present in the sample. A range of tropical and temperate Australian marine species and were selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols and known reproducibility and sensitivity as test species.

The results were combined by plotting a species sensitivity distribution to derive safe dilutions (50% confidence) which are calculated from the species protection triggers following the Warne et al. (2015) revised method for deriving ANZECC guideline values for toxicants, to obtain estimates of safe dilution.

Routine WET Testing was completed as required by the previous EP in 2017, 2014 and 2011. The 2014 results required further investigation as an additional chronic toxicity test was included but concentrations of PW tested were not low enough to enable calculation of a reliable EC10 value. An EC10 value was extrapolated but could not be incorporated into the species sensitivity distribution curve. Therefore, the safe dilutions (95% and 99%) derived using test result were not deemed reliable and the test was repeated in 2015. Despite similar chemical characterisation data (physio-chemical and toxicant) the resulting safe dilutions were notably lower in 2015 than 2014 and more in keeping with results observed prior and since. Therefore, 2015 WET toxicity testing results are used to describe the ongoing impact of PW.

Table 12-7: PC99 Concentrations and Safe Dilutions (PNEC) of the Most Recent Studies

Species Protection Level	PNEC concentrations			
PCx	**2011**	**2014***	**2015**	**2017**
PC99 (50)	0.26 (1 in 390)	0.013 (1 in 714,000)	0.0085(1 in 11,800)	0.05 (1 in 2,000)

**Addition of sensitive species to WET testing programme uncertainty in dilutions.*

Determination of Approved Mixing Zone

To determine the potential impact of the PW to the marine environment modelling was conducted to predict the distance at which safe dilutions are achieved using the most recent WET testing results available at the time to reflect the current potential toxicity. This modelling remains valid, although conservative, when considering the updated 2017 WET testing results, as the updated 2017 results are less toxic than the 2015 results. The Predicted Effect Concentration (PEC) values are based on four-day averaged PW dilution estimates to match exposure concentrations to effect concentrations (Winton et al, 2008) for each modelled location under worst-case seasonal (summer, winter and transitional) conditions. Distances from the discharge point where predicted dilutions exceed trigger values under different seasonal conditions are assessed with reference to a previous 3-D plume model for the GWA facility. The latest review of the model inputs was carried out in 2016 (Phillips, 2016).

Model simulations of dilutions were undertaken for three main seasons prevalent on the NWS, based on measured current and wind data supplied by Woodside. Ocean current data was collected at multiple depths through the water column at the North Rankin Complex (NRC). Conditions at NRC are considered representative of GWA facility due to their proximity to each other and open ocean conditions. Concurrent wind data was collected at GWA. As the modelling ocean current speed and direction varies substantially within each season, the full current records were analysed to select periods typical of the three seasons on the NWS, but erring on the side of low current speeds to give conservative model results (Jacobs, 2016).

Further to these hydrodynamic inputs, the Rob Phillips Consulting PFW discharge model was validated in 2007 using the results from a dye dispersion study (Oceanic Field Services, 2006) undertaken from the North Rankin A platform, near Goodwyn A. The predicted PFW plume dilutions reasonably matched those measured.

The modelling was updated in 2017 however the modelling presented uses the 2015 safe dilutions (Phillips, 2016).

These values are considered appropriate due to uncertainty with 2014 results as described above and the lower toxicity observed in 2017. The four-day averaged PW concentrations provide estimates of the mean in-situ exposure concentration. The four-day PEC value was used to determine the PEC/PNEC ratios and the maximum distances from the discharge point at which 99% safe dilutions (PC99%) are achieved (Table 12-8) based on the actual 2014 discharge rate (1100 m^3/day) and maximum possible discharge integrity limit rate (7500 m^3/day). The modelling shows a surface buoyant plume that is readily diluted to 99% safe dilution at 200 m under typical conditions however at maximum discharge rates this may extend to 1200 m. Indicating that the safe dilutions have historically been achieved at approved mixing zones.

The approved mixing zone boundary is 1200 m from the discharge source. Although modelling shows that safe dilutions are easily achieved at 2017 average discharge rates it is not appropriate to reduce the mixing zone boundary. Produced water rates are likely to increase as the field ages and increase flow rates may result in higher toxicity therefore for operational flexibility it is proposed to maintain a 1200 m zone to reflect 99% safe dilutions at maximum discharges the integrity limit. The approved mixing zone is suitably conservative when compared to other wastewater discharges that routinely discharge much larger quantities of residential, industrial and commercial wastewater into the marine environment.

Table 12-8: Maximum Modelled Distances at which 99% Species Protection Trigger Values are Achieved from the Discharge Point

Discharge rate (m^3/day)	Peak PW conc. at 200 m (%PW)	95%ile at 200 m (%PW)	4 day average conc. at 200 m (%PW)	Maximum distance at which PC99 PNEC achieved (i.e. PEC:PNEC = 1)
1,100	0.44	0.11	0.04	200 m
7,500	0.644	0.282	0.106	1200 m

Based on historical chemical characterisation and WET testing, it can be concluded routine PW discharge from the GWA facility poses little environmental risk at the current discharge rates with the distance to achieve safe dilutions predicted to occur within 200 m of the discharge point.

The nearest sensitive receptors are Rankin Bank and the Montebello Marine Park.

Rankin Bank is 3.5 km from the Operations Area, and approximately 30 km away from the platform where PW is discharged. As PW forms a buoyant plume which does not reach the KEF depth, no contact and therefore no change in water quality at the KEF is expected from the plume. There is potential for toxicants to settle out of the water column and impact sediment quality however given the dilutions achieved by the approved mixing zone and previous information from sedimentation studies this is not deemed likely at Rankin Bank.

The Montebello Marine Park is located 17 km from the Operations Area but over 45 km from the discharge source. Given the distance from the discharge source no impacts to the Montebello Marine Park is anticipated.

Routine monitoring (end of pipe chemical characterisation and WET testing) detects changes at the approved mixing zone boundary. If trigger values are predicted to be exceeded at this distance further investigation will be required as described above. This may include a review of single species toxicity test results, additional WET testing or insitu monitoring. If 99% species protection trigger values at 1,200 m are not exceeded there can be high confidence that maximum ecological protection is achieved by the nearest sensitive receptor.

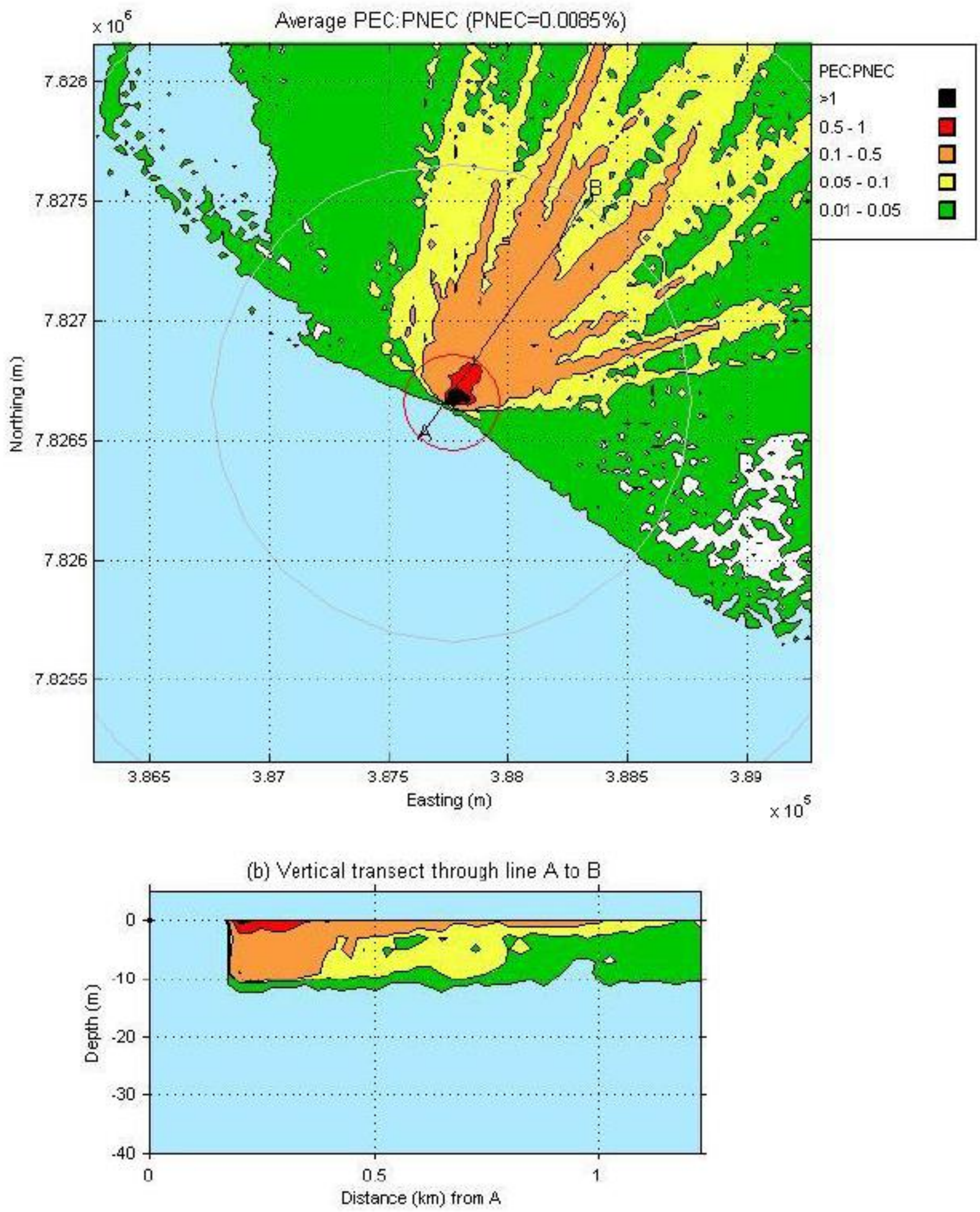

Figure 12-3: PEC/ PNEC for PW Discharge at GWA Facility 99% Species Protection at Discharge Rate of 7,500 m^3/day (grey range ring represents 1 km radius; red range ring represents 200 m radius)

Bioaccumulation

Bioaccumulation refers to the amount of a substance taken up by an organism through all routes of exposure (water, diet, inhalation, epidermal). The Bioaccumulation Factor is the ratio of the steady-state tissue concentration and the steady-state environmental concentration (assuming uptake is from food and water). The test developed to measure the ability of a substance to bioaccumulate, namely, the octanol-water partition (Pow), is based on the preferential partitioning of lipophilic organic compounds into the octanol phase. Partitioning into octanol can be correlated with the attraction for such compounds to the fatty tissue (lipid) of organisms.

The average concentration of BTEX in PW discharged from the GWA facility is approximately 13 mg/L (**Table 12-4**).

Bioaccumulation of BTEX compounds has been observed to occur in the laboratory but only at concentrations far in excess of that discharged from the GWA facility (for example refer to Berry, 1980), hence it is unlikely that BTEX would bioaccumulate at the exposure concentrations that may be experienced by biota around the GWA facility.

In contrast to BTEX compounds, PAH compounds have high Pow values indicative of the potential for bioaccumulation (Vik et al, 1996). Neff and Sauer (1996) reviewed the available literature for laboratory and field studies investigating the bioaccumulation of PAHs. The bioaccumulation values for PAHs in marine organisms collected near PW discharges in the Gulf of Mexico reported by Neff and Saur (1996) indicate that the highest bioaccumulation factor were in the tissues of bivalve molluscs and the lowest in the muscle tissue of fish.

The most comprehensive field study assessing bioaccumulation of hydrocarbons and metals from PW discharged into offshore waters is that by Neff et al (2011). At the request of the U.S. Environmental Protection Agency (USEPA), the Gulf of Mexico Offshore Operators Committee sponsored a study of bioconcentration of selected PW chemicals by marine invertebrates and fish around several offshore production facilities discharging more than 731 m^3 per day of PW to outer continental shelf waters of the western Gulf of Mexico (by comparison GWA facility discharges are currently around 1375 m^3/day). The target chemicals identified by USEPA included five metals (As, Cd, Hg, 226Ra and 228Ra), three volatile Monocyclic Aromatic Hydrocarbons (MAH), benzene, toluene, and ethylbenzene, and four semi-volatile organic chemicals (SVOC), phenol, fluorene, benzo(a)pyrene, and di (2-ethylhexyl) phthalate (DEHP). Additional MAH (m-, p-, and o-xylenes) and a full suite of 40 parent and alkyl-PAH and dibenzothiophenes were also analysed by Neff et al (2011) in PW, ambient water, and tissues at some platforms.

Concentrations of MAH, PAH, and phenol as determined by Neff et al were orders of magnitude higher in PW than in ambient seawater. There was no evidence of MAH or phenol being bioconcentrated. All MAH and phenol were either not detected (> 95% of tissue samples) or were present at trace concentrations in all invertebrate and fish tissue samples. Concentrations of several petrogenic PAHs, including alkyl naphthalenes and alkyl dibenzothiophenes, were slightly, but significantly higher in some bivalve molluscs, but not fish, from discharging than from non-discharging platforms. These PAH could have been derived from PW discharges or from tar balls or small fuel spills. Concentrations of individual and total PAH in mollusc, crab, and fish tissues were well below concentrations that might be harmful to the marine animals or to humans who might collect them for food at offshore platforms (Neff et. al., 2011).

Bioaccumulation is therefore unlikely to result in increased levels of BTEX in biota surrounding the GWA, however, there may be an elevation in PAH levels. Given the similarity of the chemical characterisation of PW discharges from the GWA facility and other nearby platforms to those elsewhere in the world including those in the Gulf of Mexico (Rob Phillips Consulting 2016), the results from Neff et al (2011) can be used to infer the very low potential for adverse bioaccumulation effects to marine organisms, or to humans, if they were to consume any affected fish, molluscs or crabs found on upper near-surface legs of the GWA facility.

The potential environmental impact associated with bioaccumulation of PW constituents in the water column is considered to be very low and limited to a potential localised effect on a small number of non-threatened species in waters immediately surrounding the facility. The potential health risk is further reduced to ALARP as a result of negligible exposure given the PSZ which prohibit fishing from or near the platform, and the absence of commercial fishing in the operational area (**Section 4.4**).

In addition to the assessment above, the findings of the field studies completed in 2015 at GWA facility (BMT Oceanica, 2015) validated the conclusion that states "the potential environmental impact associated with bioaccumulation of PW constituents in the water column and in the sediments is considered to be very low and limited to a potential localised effect on a small number of non-threated species in waters immediately surrounding each facility". Given the nature of the PW discharge from the GWA facility platform, the potential for bioaccumulation of PW contaminants (in particular BTEX) is considered to be minor and restricted to sessile organisms growing on the legs of the platform.

Potential Impacts to Sediment Quality

Potential impacts to sediment quality have been assessed through sediment surveys, including sediment surveys of the existing environment e.g. Drilling Muds. This assessment is supported by the results of Flocculation studies described in the Potential Impacts to Water Quality section.

Toxicants in Sediments

Accumulation of PW contaminants in sediments depends primarily on the volume/concentration of particulates in PW 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. As described above chemical characterisation strongly suggest that the potential for PW to impact sediment is unlikely due to the concentrations observed. As outlined below sediments near the GWA facility platform are above ISQG'S due to historical drilling activities using oil-based muds resulting in the discharge of drill cuttings and muds containing hydrocarbons. This is supported by sediment monitoring studies which indicate concentrations of barium (a component of the commonly used barite weighing agent for drilling fluids) well above background concentrations.

As part of the NWS cumulative environmental impact study (Rob Phillips Consulting 2016), sediment samples were collected in the vicinity of the GWA facility facilities in 2006 at varying distances from 100 m to 10 km along down-current and cross-current transects for the purpose of assessing impacts from hydrocarbon and metal contamination, primarily as a result from drilling activities. Chemistry analyses from these samples revealed that beyond 200 m distance from the platform, TPH concentrations were very low (typically 1 to 5 mg/kg), similar to concentrations in other non-impacted areas, and well below SQG limit (300 mg/kg) derived by CSIRO (Simpson et al 2006). A single replicate at 100 m distance away from GWA facility facilities recorded TPH concentrations similar to or exceeding the ANZECC/ARMCANZ SQG guideline, however, subsequent analyses revealed that neither PAHs nor other organic contaminants of concern were detected.

The most recent study of the sediments surrounding the GWA facility platform was conducted in February 2015 (BMT Oceanica 2015). Sediments were analysed for metals and hydrocarbons. At 400 m from the platform all metals and hydrocarbons were at background concentrations. Two separate replicates showed elevated levels of mercury and zinc at 100 m and 200 m respectively above the ISQG low trigger values (**Table 12-9**). Contaminant concentrations in sediments are influence by natural variability in sediment granulometry and mineralogical composition therefore a number of replicates are collected at each site. The mean concentrations are compared against the trigger values. Therefore no exceedances of the Simpson et al. (2013) revision of the ANZECC/ARMCANZ Sediment Quality Guidelines for mercury and zinc were observed. Woodside will develop a sampling plan to demonstrate compliance with the approved mixing zone boundary for the GWA facility sediment survey in 2021. The sampling plan will clearly outline and justify sampling locations and when concentration and bioavailability testing will occur.

Table 12-9: Mercury and Zinc Concentrations Identified in the Oceanica 2015 Sediment Sampling Study

Sample (mg/kg)	ISGQ-Low	ISGQ-High	Distance from discharge source in prevailing current direction									
			100 m			200 m			400 m			1600 m
			1	2	3	1	2	3	1	2	3	1
Mercury	0.15	1	0.18	0.05	0.05	0.02	0.02	0.02	0.02	0	0	0.01
Zinc	200	410	34	120	72	310	35	45	11	12	12	7.7

The average TPH concentrations exceeded the guideline value of 280 mg/kg at sites 100 m and 200 m from the platform, (i.e. inside the approved mixing zone), but the PAH concentrations at the same sites were below the guideline value for PAH of 10 mg/kg. BTEX concentrations were below the laboratory limit or reporting. These toxicants are therefore within the specified acceptable limits of change. Refer "Demonstration of Acceptability" for the justification on the acceptable limits of change.

The concentrations of iron, lead, zinc, mercury and TRH were higher in sediments within 200 m of the GWA facility platform compared to background concentrations and the PW stream. Sediment samples were taken within the drill cuttings pile directly beneath the platform (SKM 2014). Concentrations of metals within the samples were variable but the only exceedances from metals were mercury (0.31 mg/kg), lead (117.5 mg/kg and 53 mg/kg) and zinc (245 mg/kg). These results are consistent with sediment contamination due to the historical discharge of drill cuttings rather than PW discharge.

Table 12-10: Mercury and Zinc Concentrations Identified in the SKM, 2014 Drilling Mud Study

Sample (mg/kg)	ISGQ-Low	ISGQ-High	1-1P	1-2-P	2-1-P	2-2-P	3-1-P	3-2-P	5-1-P	5-2-P
Mercury	0.15	1	0.16	0.04	0.53	0.09	0.19	0.08	0.01	<0.01
Zinc	200	410	230	260	85	39	97	48	7.9	8.1

GWA facility sits within a KEF, the 125m Depth Contour. However, as the above section outlines, no exceedances of the Simpson et al. (2013) revision of the ANZECC/ARMCANZ Sediment Quality Guidelines for mercury and zinc have been observed. No impact to ecosystem integrity from toxicants in sediment are expected, as previous studies have shown that it is unlikely that flocculation is occurring in the receiving environment (Rob Phillips Consulting 2016).

Impact Assessment – Non Routine Activities

To deliver North West Shelf gas supply commitments it is necessary to optimize hydrocarbon recovery and allow greater ultimate recovery by preventing hydrocarbons from becoming stranded in the reservoir. It is necessary to temporarily increase water production for non-routine activities, as specified under "High Water Cut Well Unloading and Production" in (Section 3.9.2). Having temporarily high and unstable water production rates from the well and through the topsides facilities during a transient period is expected. Flexibility to allow for temporary elevated OIW levels, up to 100 mg/L, is required until steady production is established and OIW can return to the 30 mg/L, 24-hour rolling average. Where 30 mg/L OIW performance cannot be re-established after 7 days, wells will be either choked back or shut-in.

Woodside will monitor OIW concentrations, and if the daily averages indicate that the monthly 30 mg/L limit is threatened, then high water cut wells will be either choked back or shut-in.

Note that this impact assessment is not applicable to Well Clean-Up, where the 30 mg/L, 24-hr rolling average, Environmental Performance Standard remains applicable and is considered as part of impact assessment above.

Additional modelling has been undertaken to determine the impact mixing zone where PEC/PNEC ratios are expected to be achieved. While it is anticipated that OIW levels will stabilise in approximately 24-48 hours, PW discharge modelling assumed short-term high discharge volumes (7,500 m^3/day) and OIW concentrations (100 mg/L) for 24 hours, which are predicted to occur during non-routine activities. Model results included peak and 4-day average of OIW concentrations at mixing zone limits, in line with modelling for routine discharges, and are therefore representative of long-term discharges (Rob Phillips Consulting 2018). The OSPAR (2014) total hydrocarbon concentration of 70 µg/L was used as the PNEC (as there is currently no ANZECC/ARCANZ (2000) guideline value for hydrocarbons). The PNEC of 70.5 µg/L derived by Smit et al (2009) is considered more appropriate than the Tsvetnenko (1998) derived 7 ug/L as all biomarker tests used in the Species Sensitivity Distribution (SSD) were chronic as opposed to acute converted to chronic values with an acute chronic ratio (ACR) of 25 as used by Tsvetnenko.

A 24-hour period was used for modelling to align with the OIW content averaged over a 24-hour period. This is the timeframe examined to determine if the OIW content is exceeded. Hydrodynamic conditions were selected to be conservative to show the worst case (i.e. when the plume pools around the facility). Additive effects have not been observed, therefore if modelling was undertaken for a longer period no increased mixing zone would be observed. Modelling over the total discharge period would show results vary over each 24-hour period but are not any worse than that modelled for the individual 24-hour period (worst case). Modelling considered worst-case seasonal (summer, winter and transitional) conditions.

According to model results, the worst case impact occurs during the transitional period, during which PEC:PNEC=1 is achieved in 210 m, well within the approved mixing zone boundary (Rob Phillips Consulting 2018). Refer **Table 12-11**, **Figure 12-4** below for additional details.

Table 12-11: Modelled Distance at which PNEC= 70 µg/L for PW Discharged from GWA Facility During Well Unloading is Achieved (Transitional period)

Discharge rate (m3/day)	Peak OIW conc. at 200 m (ppm)	95%ile at 200 m (ppm)	24 hour average conc. at 200 m (ppm)	Maximum distance at which 70 µg/L PNEC achieved (i.e. PEC:PNEC = 1)
7,500	0.87 ppm	0.16 ppm	0.048 ppm	210 m

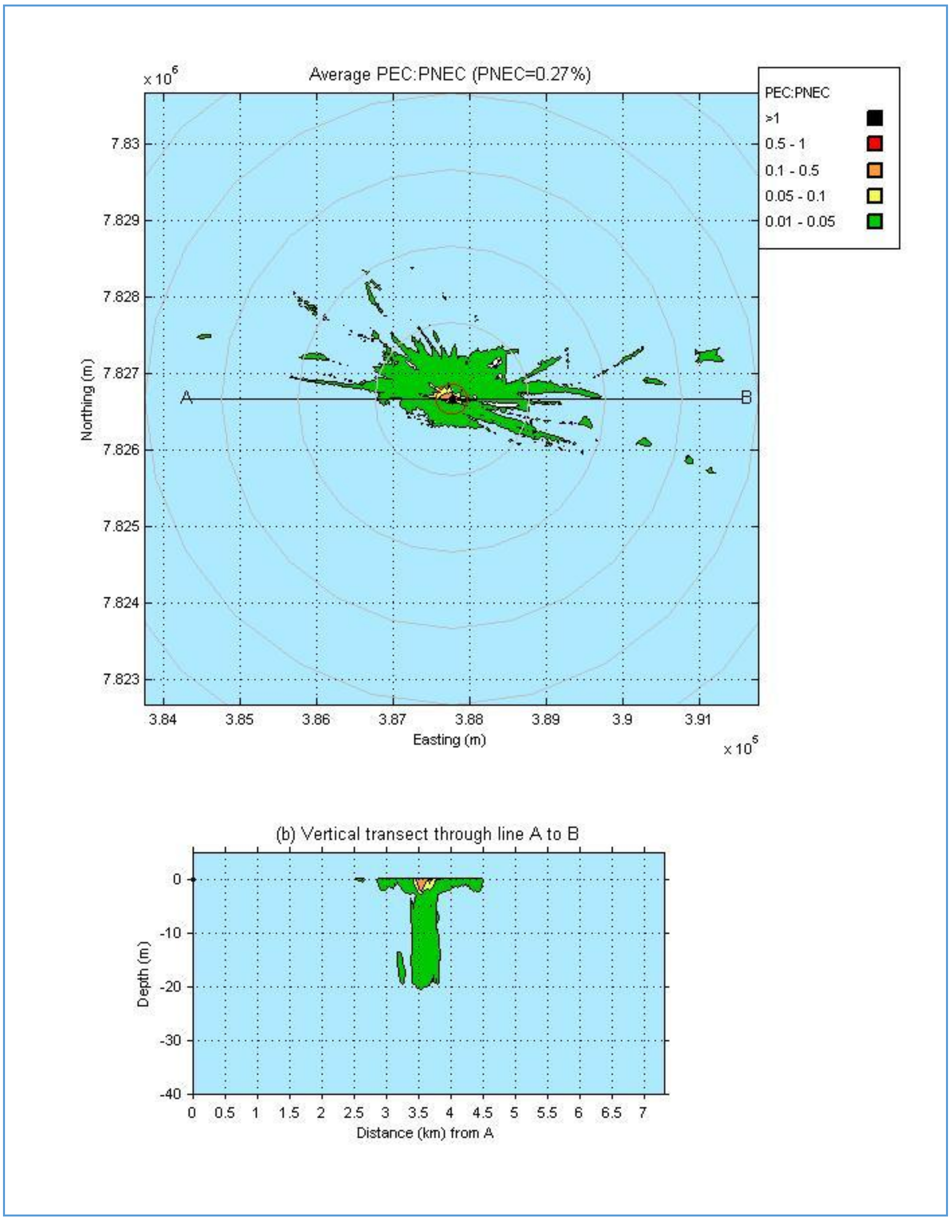

Figure 12-4: PEC/ PNEC for PW Discharge at Discharge Rate of 7,500 m^3/day (grey range ring represents 1 km radius; red range ring represents 200 m radius)

The PW discharge modelling shows that the worst-case impacts from High Water Cut Well Unloading and Production remain within the approved mixing zone boundary. Based on this assessment, the non-routine PW discharge is not predicted to result in environmental impacts beyond the defined acceptable limits of environmental impact for routine discharge of Produced Water. Further justification that the environmental impact is both ALARP and acceptable have been incorporated into the Demonstration of ALARP and Demonstration of Acceptability sections below.

Summary of Control Measures

• Chemical Selection and Assessment Environment Guideline.
  o Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control require.
  o 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.
• Monitor and manage OIW concentrations in accordance with PARCOM 1997/16 Annex 3 methodology.
  o During routine operations OIW is limited to a 30mg/L 24-hour rolling average.
  o For High Water Cut Well Unloading and Production, OIW is limited to a 100 mg/L 24-hour rolling average
  o High water cut well unloading events will be managed such that their frequency does not result in any exceedances of a monthly rolling average for OIW of 30 mg/L.
• Continuous reservoir management, i.e. changing the relative contribution to facility production of each well to maintain OIW concentrations below Performance Standards.
• Whole Effluent Toxicity (WET) testing on the PW discharge stream during initial high water cut unloading trial.
• Implementation of the Monitoring and Management Framework for Produced Water to confirm no impacts from PW beyond the approved mixing zone (1200 m)/
• Online monitoring and/or procedural controls in place to monitor and control PW discharge volume and OIW concentrations; and prevent discharge of PW with high OIW concentrations.
  o Process performance monitored by OIW concentration analyser or manual sampling, and volume meter(s) available.
• Online monitoring and/or procedural controls in place to monitor and control PW discharge volume and OIW concentrations; and prevent discharge of PFW with high OIW concentrations.
  o Conduct manual sampling on a 6 hourly basis when online analyser is offline when safe and practicable to do so.
• A technician will be available on the facility during the initial trial of high water cut well unloading activity to conduct initial calibration (using a manual system) plus hourly calibrations for the next two hours and six hourly calibrations for the duration of the well unloading activity, to ensure that OIW analyser is able to accurately measure high OIW concentrations.
• The online analyser is calibrated with a manual sample analyser in accordance with Laboratory Procedure

Routine and Non-Routine Marine Wastewater Discharges: Discharge of Sewage, Putrescible Waste, Grey Water, Blige Water, Drain Water, Cooling Water and Brine

<table>
<tr><th colspan="15">Impacts Evaluation Summary</th></tr>
<tr><th rowspan="2">Source of Impact</th><th colspan="7">Environmental Value Potentially Impacted</th><th colspan="7">Evaluation</th></tr>
<tr><th>Soil and Groundwater</th><th>Marine Sediment</th><th>Water Quality</th><th>Air Quality (incl Odour)</th><th>Ecosystems/ Habitat</th><th>Species</th><th>Socio-Economic</th><th>Decision Type</th><th colspan="2">Consequence/Impact</th><th>Likelihood</th><th>Risk Rating</th><th>ALARP Tools</th><th>Acceptability</th></tr>
<tr><td>Discharge of sewage, grey water and putrescible waste from vessels and GWA facility to the marine environment.</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td>A</td><td>F</td><td rowspan="4">Cumulative E</td><td>-</td><td>-</td><td rowspan="4">LCS
GP
PJ</td><td rowspan="4">Broadly Acceptable</td></tr>
<tr><td>Discharge of deck, bilge and drain water from vessels and GWA facility to the marine environment.</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td>A</td><td>F</td><td>-</td><td>-</td></tr>
<tr><td>Discharge of reverse osmosis brine from vessels and GWA facility to the marine environment.</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td>A</td><td>F</td><td>-</td><td>-</td></tr>
<tr><td>Discharge of cooling water from vessels and GWA facility to the marine environment.</td><td></td><td></td><td>X</td><td></td><td></td><td></td><td></td><td>A</td><td>F</td><td>-</td><td>-</td></tr>
</table>

Description of Source of Impact

Sewage, Putrescible Waste and Grey Water

Sewage and grey-water is treated onboard the GWA facility by maceration and then disposed to ocean via the sewage caisson. Putrescible wastes, such as food scraps, are also discharged via the sewage caisson from the GWA facility after being ground to < 25 mm diameter. Vessels may also discharge sewage, grey water and putrescible wastes. Sewage onboard vessels is routinely treated (either sewage treatment plant (STP) or macerator) prior to discharge. Sewage discharged from the GWA facility is macerated. Treatment systems may require routine maintenance or repair during operations, which may require infrequent, short periods in which sewage is directly discharged overboard.

The volume of sewage and grey-water generated is estimated to be in the order of 8 to 9 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 GWA facility and vessels.

Note that wastes may also be stored and transported to shore for disposal.

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. Caisson hydrocarbon levels are routinely monitored within the GWA facility CCR, trended and subject to regular pump-outs by operations as part of normal operating practices.

The drainage system on the GWA facility consists of:

- ***Non-hazardous open drains*** - which collect drainage water from non-hazardous areas and drains which are discharged directly to ocean;
- ***Hazardous open drains*** - which collect waste water, hydrocarbon and chemicals from the hazardous area via deck drains, tundishes and drip trays. Collected fluids are discharged to the hazardous open drains caisson where the fluid is allowed to weather and gravity separation occurs. Gases (from the evaporation of hydrocarbons) are directed to atmosphere via a flame arrester, while liquid hydrocarbons are recovered from the top of the caisson and pumped to waste oil isotainers for onshore disposal. Water (possibly containing water-

soluble materials) that enters the Hazardous Open Drains Caisson is discharged via the bottom of the caisson;

- ***Drilling facility hazardous open drains*** - which collect drainage water from hazardous drilling areas using a series of drains and troughs and directs the flow to the cuttings caisson. The drilling drains system was historically in service for containment of hazardous substances, hydrocarbons and associated drilling waste streams, as well as general deluge, washdown and rainwater management. GWA facility no longer maintains the capacity to drill from the platform; the drilling areas are used for general storage. Drilling infrastructure is being decommissioned, as such there are minimal hydrocarbon inventories stored in the drilling areas. Containment measures in relevant deck areas are appropriate to the volumes contained and controls are considered acceptable (work over equipment and potential small volume inventories stored are subject to temporary bunding requirements). General drain system inspections are undertaken in accordance with mechanical inspection RBI processes. Gravity separation occurs to separate water and hydrocarbons in the caisson. The liquid hydrocarbons are manually pumped out to waste oil isotainers for onshore disposal. Any water is discharged to the ocean via the bottom of the caisson. Gases (from the evaporation of hydrocarbons) are directed to atmosphere via a flame arrester; and
- ***Hazardous closed drains system*** – which collect liquids from normally pressurised and hazardous equipment prior to maintenance, and intermittent flow from other process equipment. Hydrocarbon liquids collected in the closed drains system and closed drains break drum are pumped back to the oily water drains separator under normal operational conditions (fluids reprocessed as per design, and water treated via the PW system (See previous section). The gases from the closed drains system are directed to the low pressure flare. Closed drain systems are treated as hazardous process piping and as such are considered SCE's MEE-03 and Safety Case. Performance requirements and assurance is included within scope of P08-Piping Systems Performance Standard.

Chemicals used onboard the GWA facility platform may be introduced to the environment via 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.

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. Vessels may also discharge drainage water from decks directly overboard or via deck drainage systems; deck drainage may also contain traces of chemicals. Water sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks.

Cooling Water

The seawater system is routinely used onboard the GWA facility to process and machinery cooling, which is returned to the sea via the seawater dump caisson. Seawater used for cooling is dosed with sodium hypochlorite to inhibit marine growth to a target chlorine concentration of 0.5 ppm. Seawater system discharge temperature and volumes are typically 32 °C and 4275 m^3 per hour respectively.

Brine

The RO plant onboard the GWA facility is used to produce potable water, with the brine from the RO plant discharged to the marine environment at the GWA facility. Brine from the RO plant is generally 55-60 parts per thousand salt, with approximately 75 m^3 of brine produced per day. Small quantities of anti-scaling and cleaning chemicals may also be discharged with the brine.

Impact Assessment

Sewage, Putrescible Waste and Grey Water

The 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.

No significant impacts from the planned (routine and non-routine) discharges to the marine environment 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 around the GWA facility platform (the location of the most significant routine discharges) indicates that there is no detectable decrease in oxygen saturation, nutrients or increase in oxygen demand at the GWA facility platform (BMT Oceanica 2015). This is supported by monitoring of sewage discharges, which has 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). In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were rapidly diluted and no elevations in water quality monitoring parameters (e.g. TN, total phosphorous and selected metals) were recorded above background levels at any station.

The Operational Area is located more than 12 nm from land, which exceeds the exclusion zones required by Marine Order 96 (Marine pollution prevention – sewage) 2009 and Marine Order 95 (Marine pollution prevention – garbage) 2013.

Although the NWS Province is characterised as a low nutrient environment (Department of the Environment, Water, Heritage and the Arts 2008) studies of adjacent Shelf water have found the area to be "*a highly productive ecosystem in which nutrients and organic matter are rapidly recycled*" (Furnas and Mitchell 1999). The estimated daily loading from sewage and putrescible waste (2.4 to 3.0 kg/day of TN and 0.38 to 0.43 kg of TP/day) is not significant in comparison to the daily turnover of nutrients in the area. 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 small mass, relative to daily turnover, and the assimilative capacity of the receiving environment.

Drain and Bilge Water

The impacts of drainage can include a decline in water quality and may be directly toxic to marine organisms, with impacts varying depending on volumes and type of contaminants.

Drain water from the GWA facility may contain small quantities of hydrocarbons, and other chemicals such as detergents. Drain discharge from areas with greater risk of hydrocarbon contamination is via caissons with hydrocarbon recovery systems. This means floating hydrocarbons are not routinely discharged to the environment via drains; any hydrocarbons discharged are primarily soluble fractions, with very low concentrations expected.

Water foaming agents used in aqueous firefighting foam, by nature of the surfactant properties by which it effectively extinguishes liquid fires, may be harmful to aquatic organisms within freshwater environments like ponds and streams. This surfactant effect 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. Nevertheless, the planned release of these materials is restricted to testing activities to ensure safe and effective operation of the system in an emergency.

Migrating cetaceans and fish may be present near drainage releases, and individuals may be exposed to diluted concentrations if they pass through the small discharge plume, with short-term superficial effects, and no acute or chronic impacts predicted. This is supported by water quality monitoring studies, which indicated elevated levels of potential contaminants are localised to the discharge location. Impacts from drainage water from the GWA facility are assessed as being highly localised and short-lasting.

Bilge and deck drainage water from vessels is expected to mix rapidly in the marine environment upon discharge. Given the rapid mixing, relatively small typical bilge and deck drainage water, and expected low levels of potential contaminants, impacts from bilge and deck drainage water from vessels are assessed as short-lasting and highly localised.

Cooling Water

Discharged cooling water is typically warmer than the surrounding seawater, which typically ranges from 24.3 to 28.5 °C. Given this difference in temperature, discharged cooling water is expected to be relatively buoyant compared to the receiving seawater, and will form a plume in near-surface waters down current from the discharge location. As a surface plume, discharged cooling water will be mixed by sea surface waves and wind. Monitoring of water in the mixing zone around the GWA facility indicates that water temperatures are consistent with background levels at the GWA facility platform location (BMT Oceanica 2015); no impacts from increased water temperate are expected to occur.

Sodium hypochlorite is expected to readily dissociate and break down once discharged. Monitoring of water in the mixing zone around the GWA facility has not indicated the pH of water within the mixing zone to differ from the surrounding environment (BMT Oceanica 2015); given sodium hypochlorite is basic the monitoring suggests that sodium hypochlorite concentrations diminish rapidly following discharge.

Brine

Brine plumes 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 that may move away from the brine plume; hence impacts will be 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. Monitoring of water in the mixing zone around the GWA facility confirm salinity within the mixing zone is consistent with the surrounding environment (BMT Oceanica 2015); these results provide evidence that the RO brine plume is mixed rapidly. Impacts from RO brine discharge will 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 (GWA facility) over the course of the Petroleum Activities Program; and

- Cumulative discharges from differing point sources (GWA facility 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. NRC) are expected.

Summary of Control Measures

- 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 GWA facility macerated prior to overboard discharge.
- Sewage system macerator maintained.
- Electrochlorination system used for seawater systems to control marine growth.

Facility open hazardous drain system integrity maintained, and open hazardous and closed drain caisson sump pumps available to support hydrocarbon recovery. 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
- Maintain level instrumentation to monitor and support hydrocarbon level management in Open Hazardous and Closed Drain Caissons.

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
GWA facility internal combustion engines, operational flaring and fugitive emissions, and vessel emissions (including incinerators)				X				A	F	-	-	LCS GP PJ	Broadly Acceptable

Description of Source of Impact

Atmospheric emissions will be generated predominantly from the GWA facility 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 typically include CO_2, water vapour, NO_x, SO_2, methane, refrigerant gases (including ozone depleting substances), particulates, Volatile Organic Compounds (VOCs).

Fuel Emissions: Internal Combustion Engines and Waste Incinerators

Fuel gas consumption for compression and power generation is the largest source of combustion emissions from the GWA facility, primarily used in the export compressor gas turbine and across six Solar gas turbine generators, one of which is planned to be retired following the installation of the BESS. Diesel is used for firewater pumps, emergency generators, cranes and back-up fuel for the turbine generators. In 2016/17, 63,600 tonnes of fuel gas was used on the GWA facility, the combustion of which equated to the emission of 147,038 tonnes of CO_2 equivalents. Diesel usage on the facility (excluding support vessels) in 2016/17 was 1,130 tonnes, the combustion of which equated to the emission of 3,058 tonnes of CO_2 equivalents. Fuel gas and diesel usage is not expected to significantly increase over the period in which this EP is in force.

The forecast annual emissions from fuel combustion on the GWA facility has been estimated using emissions factors (as per National Pollutant Inventory Emission Estimation Techniques and are presented in **Table 12-12**.

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 12-12: Estimated Annual Emissions from Fuel Combustion at the GWA facility (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	146,700	3,045	149,745
CH_4	11	0.2	11
N_2O	0.3	0.03	0
CO_2eq	147,000	3,058	150,058
NO_x	587	59	646
SO_x	0.9	0.2	1
CO	150	15.8	166

[1] Based on combustion of 63,600 tonnes of fuel gas during 2016/17

[2] Based on combustion of 950 tonnes of diesel during 2016/17

Operational Flaring

Gas flaring has the potential to increase the volumes of greenhouse gases emitted to the atmosphere. Flaring also consumes natural gas, a non-renewable resource. Emissions and combustion products includes CO_2, NO_x, SO_2, methane, particulates, and Volatile Organic Compounds (VOCs). Incomplete combustion under certain scenarios may also generate dark smoke.

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

- Normal operational flaring associated with flare system purge and pilot, process flows and glycol regeneration; and
- Non-routine flaring that may result from activities such as planned shutdowns and ESD testing, and un-planned shutdowns and ESDs, production restarts, equipment outage/failures, subsea flowline depressurisation and well remediation activities.

During flaring, the burnt gas generates mainly water vapour and CO_2. It is estimated that between 10,000 and 17,000 tonnes of gas is flared per year (**Table 12-13**). Flaring volumes will vary as a result of production rates and non-routine activities, outages and shutdowns. The forecast annual atmospheric emissions from flaring have been estimated using the National Pollutant Inventory Emission Estimation Techniques.

Table 12-13: Estimated Annual Atmospheric Emissions from Flaring at the GWA Facility

Component	Estimated lower flaring emissions (tonnes) [1]	Estimated upper flaring emissions (tonnes) [2]
CO2	*27,000*	*45,900*
CH4	*1,000*	*1,700*
N2O	*300*	*510*
CO2eq	*28,300*	*48,110*
NOx	*15*	*26*
SOx	*0*	*0*
CO	*87*	*148*

Reference: NPI EET Manual for Oil and Gas v2.0 2013, Table 8

[1] *Based on lower flare estimate (10,000 tonnes hydrocarbon)*

[2] *Based on upper flare estimate (17,000 tonnes hydrocarbon)*

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 GWA 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 (days) low-rate release of hydrocarbon gas to the atmosphere. Intermittent venting from the GWA facility represents only a minor source of atmospheric emissions and is not considered to pose a risk beyond the routine air emissions described in this section.

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 and the normal approach, as accepted by the National Greenhouse and Energy Reporting scheme, is to indirectly estimate amount of emissions based on product throughput.

As much of the safe operation of the GWA facility relies on the effective containment of hydrocarbons, the volumes of routine and non-routine fugitive emissions are considered to be small (Refer to **Unplanned Activities** for potential atmospheric unplanned hydrocarbon releases associated with accidents, incidents and emergency situations). The Department of the Environment and Energy (DoEE) have released technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia, including from fugitive emissions. Using these estimation techniques, GWA facility reported 4 tonnes of gas lost through fugitive emissions in FY2016/2017. This equates to approximately 97 tonnes of CO_2 equivalents.

Discrete relatively small volumes of packed gases and charged systems including refrigerant gases are used across the GWA facility and vessels which have potential for small volume leaks (typically less than 100 kg per isolatable inventory). Refrigerants used include those with low ozone depleting potential and global warming potential. The GWA facility is fitted with a gaseous fire extinguishing system utilising CO_2 and FM200. FM200 has zero ozone depleting potential and a low global warming potential. The gaseous fire extinguishing agents are only released as demanded by the applicable safety system or as per certification testing requirements.

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. Platform 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 GWA 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, the Montebello Islands, lies approximately 59 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 GWA facility air emissions; 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 platform. Air emission impacts are not expected to have direct or cumulative impacts on sensitive environmental receptors, or above National Environmental Protection (Ambient Air Quality) measures. Additionally, air quality around the GWA facility platform is maintained to provide a safe working environment for operational staff. The flare and potential black smoke resulting from emissions may impact visual amenity. The offshore location of the Petroleum Activities Program is not directly visible from the nearest landfall (Montebello Islands, 59 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

• Contract vessels compliant with Marine Order 97 (Marine Pollution Prevention – Air Pollution).
• National Greenhouse and Energy Reporting Scheme (NGERS) and National Pollutant Inventory (NPI) reporting
• Regular monitoring, estimation and reporting of facility fuel and flare emissions (in accordance with NGERS/NPI) to inform optimisation management practices.
• Pursue cost effective fuel/power substitution:
  o Fuel gas used in preference to diesel for power generation; and
  o Pursue battery energy storage system (BESS) project.
• Maintain flare to maximise efficiency of combustion and minimise venting.

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 GWA facility and vessels.						X		A	F	-	-	LCS GP PJ	Broadly Acceptable
Light emissions from GWA facility during flaring.						X		A	F	-	-		

Description of Source of Impact

Lighting is used to allow safe operations during night hours, as well as to communicate the presence of the GWA facility and vessels to other marine users (i.e. navigation lights). Lighting is required for the safe operation and cannot reasonably be eliminated.

External lighting is located over the entire GWA facility, as well as vessels, with most external lighting directed towards working areas such as the production deck of the GWA facility, or the back deck of vessels. The production deck of GWA facility is approximately 25 m above sea level, with the highest point of the facility (the top of the flare tower) reaching approximately 175 m above sea level. External lighting is typically lower than the GWA facility lights, with vessel lighting usually reduced to improve night vision of bridge crew.

The distance to the horizon at which components of the GWA facility platform will be directly visible can be estimated using the formula below:

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

Where horizon distance is the distance to the horizon at sea level in kilometres and height is the height above sea level of the light source in metres. Using this formula, the approximate distances at which the production deck and flare tower top will be visible at sea level are:

- Production deck: approximately 18.25 km from GWA facility platform; and
- Flare tower tip: approximately 48 km from GWA facility platform.

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 will be 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 nighttime 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*: organisms such as marine turtles and birds may also use lighting from natural sources to orient themselves in a certain direction at night. In instances where an artificial light source is brighter than a natural source, the artificial light may act to override natural cues leading to disorientation.

The fauna within the Operational Area 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 Area. Additionally, there is no known critical habitat within the Operational Area for EPBC listed species, although there are BIAs listed in **Section 4.3.4** that overlap the Operational Area. Given the lack of significant fauna populations expected to occur within the Operational Area, impacts from light emissions are considered to be highly unlikely.

Seabirds

The risk associated with collision from seabirds attracted to the light is considered to be low given the 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 Montebello Islands, lie approximately 59 km south 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.

Wiese et al. (2001) presented a literature review relating to the effect of light from platforms in the North Sea on seabirds. They noted that seabirds are strongly visually orientated and that large attractions of birds, and in some cases mortality of birds, have often been documented by lighthouses, communication towers, buildings and oil platforms. Injuries can occur through direct collisions and the rate of collision is (they inferred from literature) related to the cross-sectional area of the obstacle, amount of light and number of birds present.

Black (2005) reported on two cases of mass seabird mortalities from striking of ships in the Southern Ocean. In both cases, mortalities occurred when the vessel was at anchor near seabird colonies and conducting night deck operations during periods of reduced visibility. As such, impacts from the presence of vessels on seabirds is expected to be a localised behavioural disturbance to a small number of birds, with no lasting effect. Note significant seabird mortality in relation to fishing vessel operations has been documented (e.g. Sullivan et al. 2006), with interactions with fishing gear (e.g. trawl nets) the primary source of mortality; note birds are strongly attracted to bycatch / baits from fishing vessels. Hence, comparisons of bird mortality between fishing vessels and vessels undertaking the Petroleum Activities Program are not reasonable due to the difference in the nature and scale of the risks and impacts.

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. They hypothesise that when such offshore platforms are on long-distance bird migration routes, the impact of this attraction could be considered highly significant as many birds cross the ocean with twelve hours of fat reserves, for instance, for a ten-hour flight. Any delay (e.g. resting on a platform or circling around them) could reduce the bird's resilience and potential survival. Migratory shorebirds travelling the East Asian-Australasian Flyway may transit through the Operational Area 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. However, the possibility of this occurring in the GWA facility Operational Area is considered to be extremely low as migrating birds in the region are at or near the end of their migration (or staging area) and if any are attracted to the platform, they will not be facing long-distance journeys directly upon leaving the facility. The environmental impact associated with seabirds attracted to the light, and hence diverted from their migratory pathway is considered to be insignificant.

Marine Turtles - Hatchlings

The nearest potential nesting site in relation to the Operational Area are the Montebello Islands, approximately 59 km from the Operational Area, and approximately 89 km from the GWA facility. Lighting and the tip of the flare tower will not be directly visible from this potential nesting site.

Light emissions reaching turtle nesting beaches is widely considered detrimental owing to interference with important nocturnal activities including choice of nesting sites and orientation/navigation to the sea by post-nesting females and hatchlings (Lorne and Salmon 2007, Salmon 2003, Tuxbury and Salmon 2005). Hatchling turtles use light as a visual cue to orientate themselves towards the sea during the post-hatching dash after emerging from the nest, orientating themselves towards the relatively bright horizon above the sea and away from the relatively dark dunes (Salmon et al. 1995b, Salmon and Witherington 1995). Artificial light from coastal developments has been identified as potentially misorientating hatchling turtles during the post-hatching movements, with hatchling turtles orientated towards artificial light sources away from the sea (Lorne and Salmon 2007, Salmon 2003, Tuxbury and Salmon 2005). Turtles disorientated by artificial lighting may take longer, or fail, to reach the sea, potentially resulting in increased mortality through dehydration, predation or exhaustion (Salmon and Witherington 1995).

Once hatchling turtles reach the sea, the primary cue for hatchling turtle orientation is water movement, with hatchlings swimming directly towards oncoming waves (Lohmann et al. 1990, Lohmann and Lohmann 1992). Hatchling and adult turtles may also use the Earth's magnetic field for larger scale navigation (Lohmann and Lohmann 1996). As such, hatchling turtles are only likely to be disorientated by artificial light between leaving the nest and reaching the sea.

Given the nature of the light emitted from the GWA facility and vessels, and the distance to the nearest landfall (and nearest significant rookeries), artificial light from the GWA facility and vessels is not expected to be directly visible to hatchling turtles. As such, the potential for hatchling turtles to become disorientated by artificial lighting from GWA facility or vessels is considered to be remote.

Marine Turtles - Adults

Artificial lighting may affect the location that turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon et al. 1995a, 1995c, Salmon and Witherington 1995). Such lighting is typically from residential and industrial development overlapping the coastline, rather than offshore from nesting beaches. The Operational Area does not contain any known critical habitat for any species of marine turtle, with the nearest potential nesting site approximately 59 km from the Operational Area (the Montebello Islands). It is acknowledged that marine turtles may be present in the Operational Area in low densities and that an internesting buffer for flatback turtles overlaps the Operational Area, however no impacts to nesting flatback turtles will occur due to light generated during the Petroleum Activities Program. **Fish** Lighting from activities in the Operational Area may result in the localised aggregation of fish below the source of light. Note fish may also be aggregating around the GWA facility platform due to the habitat provided by the facility and subsea infrastructure. These aggregations of fish would be confined to a small area. Any long term changes to fish species composition or abundance is highly unlikely.
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 ER	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

Bunkering of marine diesel between the platform support vessels and the GWA facility platform routinely occurs during the Petroleum Activities Program, along with bulk transfers of chemicals such as glycol (MEG and TEG).

Marine Diesel Bunkering/Refuelling

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 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break and complete loss of hose volume); and
- 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, resulting in approximately 8 m^3 marine diesel loss to the deck and/or into the marine environment.

Mechanisms are available to capture diesel from process/piping associated with bunkering and fuel transfers, which can be used to drain to a caisson with an oil recovery system. The diesel unloading stations have isolation and vent valves to allow draining of bunkering hoses between uses.

Bulk Chemical Transfer

Bulk transfer of MEG and TEG between platform support vessels and the GWA facility, occurs typically in smaller quantities than diesel. Similar to a spill event during refuelling, the most likely spill volume of MEG / TEG is likely to be less than 0.2 m^3 based on the volume of the transfer hose and the immediate shutoff of the pumps by personnel involved in the bulk transfer process. However, the worst-case credible spill scenario could result in up to 8 m^3 of MEG / TEG being discharged. This unlikely scenario represents a complete failure of the bulk transfer hose combined with a failure to follow procedures (which require transfer activities to be monitored), coupled with a failure to immediately shut off pumps.

Chemicals Use and Storage

Chemicals will be used during the Petroleum Activities Program for a variety of purposes (refer to **Section 3.8.2**).

Spills of chemicals (including non-process hydrocarbons) can originate from stored hydrocarbons/chemicals or equipment on the platform, vessel decks or subsea.

Operational process chemicals are typically stored in dedicated vessels which have similar controls of those related to mitigating hydrocarbon releases (e.g. dedicated tanks, permanent piping to the process, isolatable by valves etc.). The chemicals stored in the largest volumes on the GWA facility are MEG and TEG, both operational process chemicals stored in bulk (30 m^3 and 23 m^3 respectively). The MEG and TEG tanks are classified as a pressure vessel, as such are covered under P01 - Pressure Vessels technical performance standard. The vessels are considered SCEs (primarily for MAE) as they are provided with a hydrocarbon gas blanket from the fuel gas system. P01 is a SCE included in MEE-03, as assurance of the MEG tanks (pressure vessels) provide protection for escalation events under MEE-03 Topsides Loss of Containment, and as a barrier to prevent potential escalation to loss of structural integrity MEE-04. Inherent to the nature of explosion/gas LOC risks, the design of the vessel and associated integrity SCE assurance provides a robust prevention regime associated with the potential loss of containment to sea risk posed by

MEG or TEG (which are classed as PLONAR).

Selection of operational chemicals and those used during IMR activities is undertaken in accordance with the Woodside Chemical Selection and Assessment Environment Guideline.

The GWA facility and Platform Support Vessels also store other non-process chemicals and hydrocarbons in bulk, in various volumes (up to approximately 6000 L). Operational non-process chemicals and maintenance chemicals present on the GWA facility and support vessels are generally held in low quantities (usually less than 50 L).

Subsea Support Vessels undertaking IMR activities may also store quantities of chemicals for subsea use. 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). Subsea operational chemicals are subject to the chemical selection process outlined in **Section 3.8.2**.

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 refueling of equipment, which can either be located within bunded/drained areas or outside of bunded/drained areas (e.g. over grating on cranes).

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.

Quantitative Spill Risk Assessment

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

Hydrocarbon Characteristics

Refer to **MEE-03** for a description of the characteristics of marine diesel, including detail on the predicted fate and weathering of a spill to the marine environment. Note the marine diesel scenario considered in Loss of Well Control Section is significantly larger than the volumes considered here.

Consequence Assessment

Marine Diesel

The biological consequences of a small volume marine diesel spill on identified open water sensitive receptors relate to the potential for minor consequences to megafauna, plankton, water quality and pelagic fish populations (surface and water column biota) that are within the spill affected area. No consequences to commercial fisheries are expected.

A spill of marine diesel may have an acute impact on the water column biota within the immediate vicinity of the spill. However, considering the hydrocarbon type weathering and spreading is expected to be rapid with consequences limited to minor and short term.

Refer to the Summary of Potential Impacts to environmental values(s) within Loss of Well Control section for a description of the impacts of hydrocarbons on the above species (*Note - the, the extent of the ZoC associated with a marine diesel spill from loss during bunkering will be much reduced in terms of spatial and temporal scales and hence, potential consequences from bunkering are considered minor and short-term*).

Chemicals and Non-Process Hydrocarbons

MEG and TEG are miscible in water and are considered PLONOR. A maximum credible spill of MEG or TEG is expected to mix with the receiving environment with no lasting environmental impact.

Accidental releases of chemicals or non-process hydrocarbons decrease the water quality in the immediate area of the release; however, the consequence is expected to be slight given the temporary and localized nature due to water depths, 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.

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 and hydrocarbons will be stored safely to prevent the release to the marine environment.
- Incident reports are raised for unplanned releases within event reporting system.

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	E	2	M	LCS GP PJ	Broadly acceptable

Description of Source of Risk

Non-hazardous and Hazardous Waste

Normal operations on the GWA facility and support vessels results in a variety of hazardous and non-hazardous wastes. These materials could potentially impact the marine environment, if incorrectly disposed of, lost overboard, or discharged in significant quantities.

Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard, scrap steel. Hazardous wastes include recovered solvents, excess or spent chemicals, oil contaminated materials (e.g. sorbents, filters and rags), batteries, used lubricating oils and potentially material containing Naturally Occurring Radioactive Material (NORMs)[8]. Sand and sludges may also be periodically generated during well clean-up operations, desanding and vessel maintenance. All waste materials not suitable for discharge to the environment, including hazardous wastes (i.e. liquid and solid wastes), generated on GWA facility are transported to shore for disposal or recycling by Woodside's 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 marine environment, and secondary impacts relating to potential contact of marine fauna with wastes resulting in entanglement or ingestion leading to injury and death of individual animals. Solid material accidently lost to the marine environment could potentially lead to slight localised contamination of benthic sediments. The temporary or permanent loss of waste materials into the marine environment is not likely to have a significant environmental impact, based on the location of the Operational Area, the types, size and frequency of wastes that could occur and 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[9] environmentally hazardous or non-hazardous solid object/waste container lost overboard. Incident reports are raised for unplanned releases within event reporting system.

[8] Laboratory analyses results of material produced from the desander (refer to **Section 3.5.5**) are consistent with the Exempt Waste category as per the Australian six-tier radioactive waste classification scheme (i.e. very low levels of radioactivity; thus waste is managed and disposed of similar to the process applied for non-radioactive waste). The results also support the understanding that sand generated from the GWA facility contains little to no NORMs.

[9] *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 factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours.

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, Laist et al. 2001). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. According to the data of Vanderlaan and Taggart (2007), it is estimated that the risk is less than 10% at a speed of 4 knots. Vessel-whale collisions at this speed are uncommon and, based on reported data contained in the US National Ocean and Atmospheric Administration database (Jensen and Silber 2004) there only two known instances of collisions when the vessel was travelling at less than 6 knots, both of these were from whale watching vessels that were deliberately placed amongst whales. 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 aggregation areas (resting, breeding or feeding) are located within or immediately adjacent to the Operational Area. The nearest recognised BIAs for cetaceans (considered to be at risk due to relatively slow movement and proportion of time spent at or near the sea surface) is the humpback whale migration BIA, which lies approximately 23 km south of the Operational Area (refer to **Section 4.3.4**). Note that the pygmy blue whale migration BIA also lies beyond the Operational Area (approximately 27 km north-west). Adverse interactions between vessels and humpback or pygmy blue whales are considered to be unlikely. Whale sharks are at risk from vessel strikes when feeding at the surface or in shallow waters (where there is limited option to dive). Whale sharks may traverse offshore NWS waters including the Operational Area during their migrations to and from Ningaloo Reef and a BIA for foraging whale sharks overlaps with the Operational Area. However, it is expected that whale shark presence within the Operational Area would not comprise of significant numbers 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 (i.e. no emergent islands, reef habitat or shallow shoals) and the water depth (approximately 130 m), it is considered that the Operational Area is unlikely to represent important habitat for marine turtles. An inter-nesting buffer BIA for flatback turtles overlaps the Operational Area; the nearest potential nesting habitat are the Montebello Islands (approximately 59 km south of the Operational Area). As such, 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 to be highly unlikely. It is not deemed credible, that vessel movement associated with the Petroleum Activities Program could have a significant impact on marine fauna populations given (1) the low presence of transiting individuals, (2) avoidance behaviour commonly displayed by whales, whale sharks and turtles and (3) 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		A	E	1	L	LCS GP PJ	Broadly Acceptable

Description of Source of Risk

The GWA facility relies on a number of vessels to service routine needs (platform support vessels, refer to **Section 3.6**) and, less frequently, to provide specialist services (subsea IMR activities etc.) (subsea support vessels, refer to **Section 3.6**). Vessels may be sourced from the local area (Dampier, Port Hedland, etc.) or from further afield, depending on the type of vessel required and availability. In addition, infrequent import of materials (e.g. spares) from international suppliers may be required.

All vessels are inherently 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.). Organisms can also be drawn into ballast tanks during on-boarding of ballast water as cargo is unloaded or to balance vessels under load.

Non-indigenous Marine Species (NIMS) have been introduced into a region beyond their natural biogeographic range and have the ability to 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 and few have spread widely beyond sheltered ports and harbours. Only a subset of NIMS that become abundant and impact on social/cultural, human health, economic and/or environmental values can be considered IMS.

During the Petroleum Activities Program, the following vessel activities have the potential to lead to the introduction of Invasive Marine Species (IMS):

- Discharge of ballast water from vessels; and
- Vessel interactions with nearby fixed infrastructure/GWA facility platform.

The majority of vessels used during the Petroleum Activities Program are platform support vessels; these are typically sources from Australia and are not considered high risk for IMS introduction.

Consequence Assessment

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;
- Are likely to survive and establish in the region; and
- Are able to spread by human mediated or natural means.

Species of concern vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities.

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 like coastal or sheltered nearshore waters, the deep offshore open waters of the Operational Area are not conducive to the settlement and establishment of IMS (Geiling 2016), due to the lack of light or suitable habitat to sustain growth or survival. The Petroleum Activities Program will be undertaken in an open ocean, offshore location more than 12 nm from shorelines and/or critical habitat and in waters approximately 79 to 131 m deep.

When examining potential impacts from translocation of marine pests to the GWA facility itself. Interactions with the facility and any support vessels (most likely Australian sourced) will be limited. With time within the 500 m safety exclusion zone around the facility limited to vessel transfers/bunkering. This risk of this occurring is however considered manageable given ballast water and biofouling controls which will be 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 79 – 131 m deep are not conducive to the settlement and establishment of IMS.		
Transfer of IMS from infected vessel to and subsequent establishment on the GWA facility platform.	**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 would likely result in the quarantine of the GWA facility until eradication could occur (through cleaning and treatment of infected areas), which would be costly to undertake. Such introduction would be expected to have Minor (D)	Highly Unlikely (1) Interactions between the GWA facility and support vessels will be limited during the petroleum activity program, with a 500m safety exclusion zones being adhered too. Spread of marine pests via ballast water or spawning in these open ocean environments is considered Highly Unlikely (1).

		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 GWA facility platform is considered Slight (E), localised and would relate to habitat directly on the GWA facility.	
Transfer of IMS from infected vessel to and subsequent establishment on GWA facility platform, then transfer of IMS to a secondary vessel from the GWA facility.	**Not Credible** Risk is considered so remote that it is not credible for the purposes of the Petroleum Activity Program. The transfer of a marine pest from an infected activity vessel to the GWA facility was already considered highly unlikely given the offshore open ocean environment. For a marine pest to then establish into a mature spawning population on GWA facility and then transfer to another support vessel is not considered credible (i.e. beyond the Woodside risk matrix). The GWA facility is located in an offshore, open ocean, deep environment. Support vessels only spend short periods of time alongside GWA facility (i.e. during backloading or bunkering activities). There is also no direct contact (i.e. they are not tied up alongside) during these activities. Its' also noted that Woodside has been conducting marine vessel movements between the GWA facility 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.

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 platform well containment.		X	X	X	X	X	X	B	B	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Release of hydrocarbons resulting from loss of subsea well containment.		X	X	X	X	X	X	B	A	1	H		
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, (well blowout). Woodside has identified a well blowout as the scenario with the worst case credible environmental outcome as a result of this event. Due to the potential consequences, a loss of well containment is considered to be a MEE (MEE-01). A loss of well containment could occur due to a variety of causes including:

- internal corrosion;
- external corrosion;
- erosion;
- overpressure of the annuli;
- fatigue;
- loss of well integrity during interventions;
- premature detonation of explosives; 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**.**

There are three escalation scenarios (from other MEEs) that can also lead to loss of well containment on the GWA platform, including:

- loss of structural integrity (MEE-04);
- loss of marine vessel separation (MEE-05); and
- loss of control of suspended load from facility lifting operations (MEE-06).

Loss of Well Containment – Credible Scenarios

The Petroleum Activities Program includes production from a series of platform and subsea wells (**Section 3.4.2**). 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.

As a number of wells are platform wells, the GWA facility was selected as the release location for Scenario 1. The credible worst-case subsea release was based on the maximum credible release volume from the highest flow rate subsea well (Scenario 2). Each of the loss of well containment scenarios 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 B** for additional discussion of relief well timing). The characteristics of each of these release scenarios are summarised in **Table 12-14**. The characteristics of GWA condensate were used as the basis in the modelling for Scenario 1, and the characteristics of GWF-1 condensate were used for Scenario 2; refer to **Section 5.4** for additional information on modelling methods and environmental impact, thresholds and hydrocarbon characteristics justifications.

Table 12-14: 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)
Scenario 1 – Well blowout at surface – platform wellhead release	GWA condensate	3,182	77	surface	19° 39' 8"	115° 55' 47"	245,000
Scenario 2 – Well blow-out at seabed – subsea well with highest flow rate	GWF-1 condensate	2,404	77	125	19° 45' 44" S	115° 53' 24"	185,141

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in well design and construction. In the company's recent history, it has not experienced any well integrity events that have resulted in significant releases or significant environmental impacts. The GWA 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 (described in **Section 5.2)** 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 a Major Environment Event (MEE-01). The hazard associated with this MEE is hydrocarbons in reservoirs, wells, wellheads and xmas trees for GWA platform wells or subsea wells tied-back to the GWA platform.

Quantitative Spill Risk Assessment

Spill modelling of each of the worst case credible loss of well containment spill scenarios was undertaken by RPS APASA, on behalf of Woodside, over a 77-day simulation length to determine the fate of hydrocarbons released in each scenario 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 volumes for all loss of well containment scenarios.

Hydrocarbon Characteristics

Both GWA and GWF-1 condensates have a low ashpaltene (<0.1%) and wax (~0.2-0.9%) content, meaning they are unlikely to take up water and corm a water in oil emulsion and there is a low potential for residual hydrocarbons to be found as wax in the marine environment if these condensates are spilled.

The condensates contain a low proportion (<3% by mass) of residual hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment; however, the majority of the hydrocarbons that comprise these condensates will volatilise at ambient temperatures.

GWA Condensate will have a tendency to evaporate rapidly, with around 91% of the spilled volume predicted to evaporate in the first 24 hours for the variable-wind case (**Figure 12-5**).

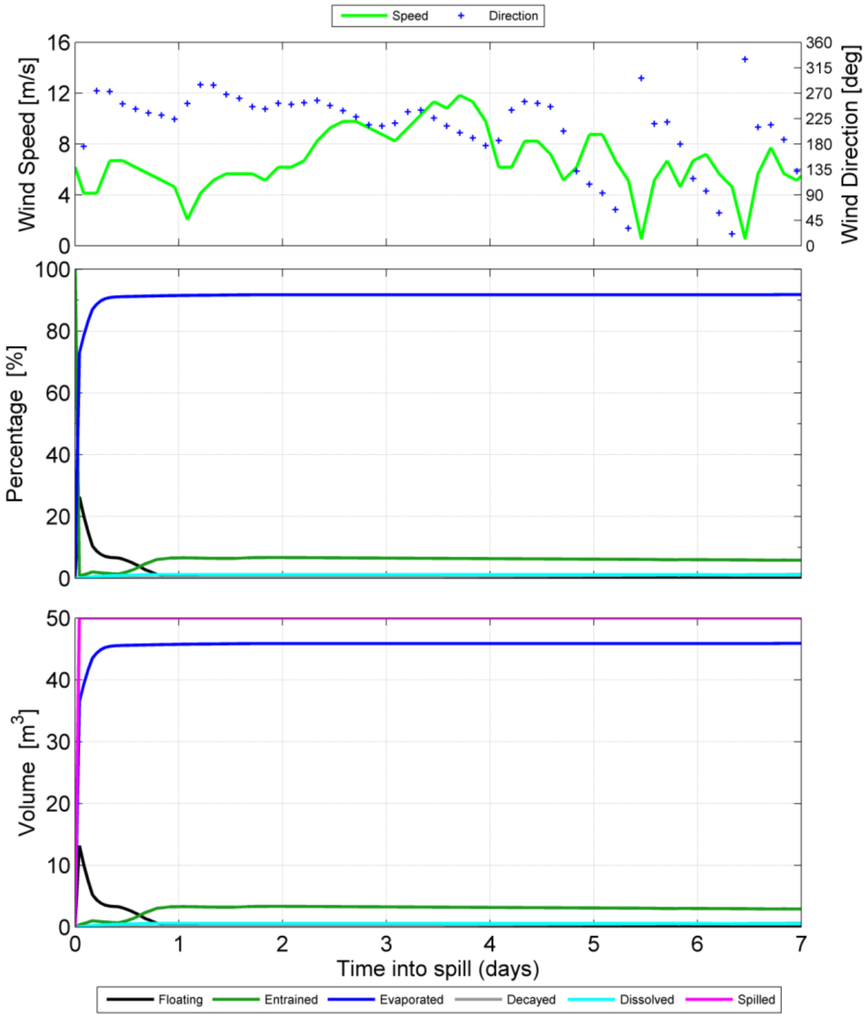

Figure 12-5: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of GWA Condensate spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to variable winds (top panel) at 27 °C water temperature

GWF-1 Condensate will have a tendency to evaporate rapidly, with around 87% of the spilled volume predicted to evaporate in the first 24 hours for the variable-wind case (**Figure 12-6**).

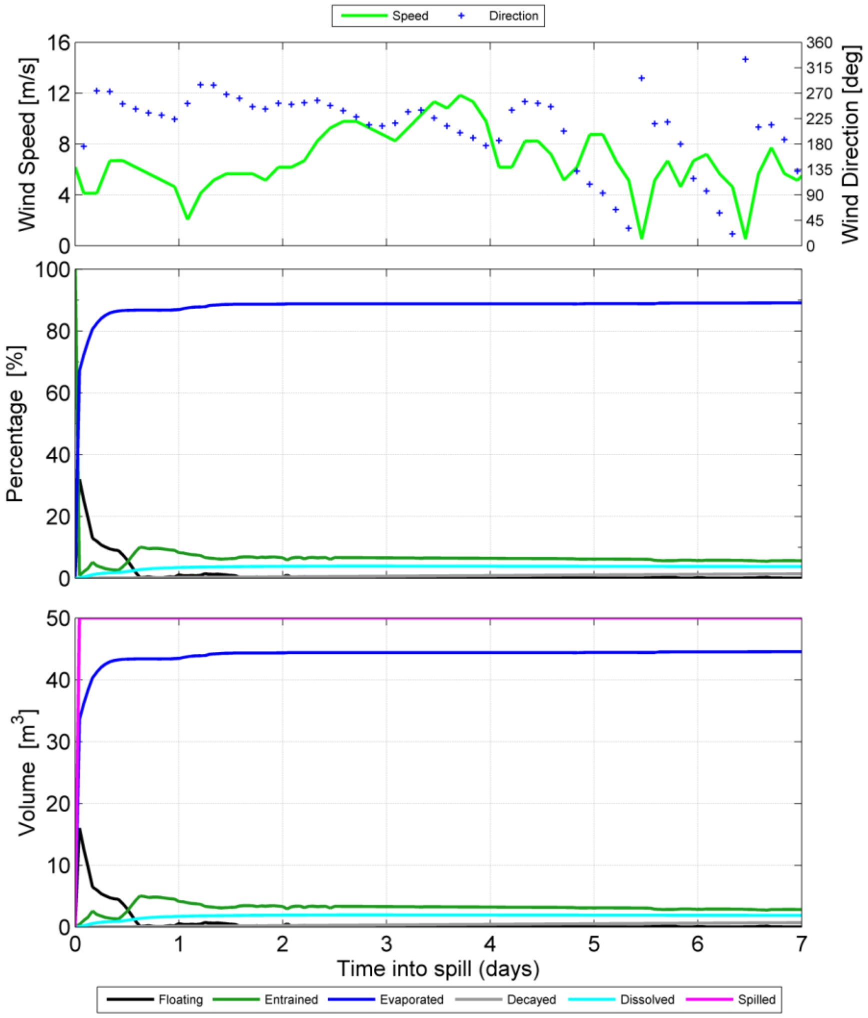

Figure 12-6: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of GWF-1 Condensate spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to variable winds (top panel) at 27 °C water temperature

Subsea Plume Dynamics

The subsea loss of well containment scenario (Scenario 2) will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model (summarised in **Table 12-15**).

Table 12-15: Inputs and outputs for OILMAP-Deep model for Scenario 2

	Parameter	Scenario 2
Inputs	Release depth (m below sea level)	125.0
	Oil density (g/cm^3) (at 15°C)	0.7802
	Oil viscosity (cP) (at 15°C)	0.9713
	Oil temperature (°C)	25
	Gas:oil ratio (m^3/m^3) [scf/bbl]	3580 [20,094]
	Oil flow rate (m^3/d)	2374 [14,930]
	Hole diameter (m) [in]	0.121 [4778]
Outputs	Plume diameter (m)	16.1

	Plume height (m above sea bed)	125.0 (surface)
	Plume initial rise velocity (m/s)	12.5
	Plume terminal rise velocity (m/s)	10.0
Predicted oil droplet size distribution	21.4% droplets of size (µm)	0.6
	31.1% droplets of size (µm)	1.3
	24.7% droplets of size (µm)	1.9
	15.1% droplets of size (µm)	2.5
	7.7% droplets of size (µm)	3.2

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.

Review of industry statistics indicates that the probability of a loss of well containment for production wells is low (10.6% of 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).

When considering likelihood from an 'Experience' perspective, the review also concluded:

- When considering likelihood of the environmental consequence of the blowout event, historic blowouts that have had catastrophic impact to the environment ('A' consequence rating) have not occurred many times in the industry. This also further supports the likelihood ranking of 'Highly Unlikely.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case loss of well containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (**Section 5.4**) and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment

Zone of Consequence

Surface Hydrocarbons

No surface hydrocarbons above impact thresholds are expected to occur for the subsea release scenario (Scenario 2).

For modelled Scenario 1 the hydrocarbon slick 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 125 km from the release site. Due to volatile, non-persistent nature of the condensates modelling, surface hydrocarbons are expected to readily evaporate, resulting in the surface ZoC being relatively small compared to the dissolved and entrained ZoCs (discussed further below).

Entrained Hydrocarbons

Modelling results indicated a number of environmental sensitivities may be contacted by entrained hydrocarbons above impact thresholds, with time to contact ranging from 0.3 days (Rankin Bank) to 86 days (Abrolhos Islands). In the event of a worst-case loss of well containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up to 1150 km from the release site. The most likely direction of drift is south-westerly around the Ningaloo Coast and then southwards, reflecting the prevailing current patterns. Results also indicate that entrained oil may also be likely to drift towards the northeast and in the offshore directions at lower probabilities.

Dissolved Hydrocarbons

In the event of a loss of well containment scenario occurring, dissolved hydrocarbons at or above 500 ppb (environmental impact threshold) are forecast to potentially occur up to 850 km from the release site.

Accumulated Hydrocarbons

Quantitative hydrocarbon spill modelling results for maximum local accumulated hydrocarbon concentrations indicated that the following sensitive receptors have potential to experience shoreline accumulation above environmental impact threshold concentrations (100 g/m^2):

- Montebello Islands (338 g/m^2 maximum);

• Barrow Island (207 g/m^2 maximum); and • Lowendal Islands (132 g/m^2 maximum). Given the low persistent fraction of the hydrocarbons that may be released by a loss of well containment, accumulated hydrocarbons are not expected to persist once stranded.

Table 12-16: 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 (WM0000PG10055394))																													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 reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and interesting 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[10]	Commonwealth waters	1,2	1,2					1,2		1,2					1,2	1,2				1,2	1,2	1,2	1,2	1,2		1,2		1,2		1,2		1,2		
	Agro-Rowley Terrace CMP	1,2						1,2							1,2	1,2			1,2			1,2	1,2	1,2		1,2			1,2			1,2		
	Montebello CMP	1,2	1,2	1,2			1,2	1,2							1,2	1,2			1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2			1	1	
	Dampier CMP	2	2					2		2					2	2			2	2		2	2	2	2	2			2			2		
	Ningaloo CMP	1,2	1,2					1,2		1,2					1,2	1,2			1,2		1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	
	Gascoyne CMP	1,2	1,2												1,2	1,2			1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2	1,2		1,2	2	
	Shark Bay CMP	1,2	1,2					1,2							1,2	1,2			1,2	1,2		1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	
	Abrolhos CMP	1,2	1,2					1,2							1,2	1,2		1,2		1,2		1,2	1,2	1,2	1,2	1,2			1,2			1,2		
Oceanic Reefs and Offshore	Rowley Shoals	1,2	1,2	1,2			1,2	1,2		1,2						1,2			1,2	1,2		1,2	1,2	1,2	1,2			1,2	1,2			1,2		
Submerged Shoals and banks	Rankin Bank	1,2	1,2	1,2			1,2	1,2		1,2						1,2				1,2		1,2		1,2	1,2	1,2		1,2			1	1,2	1,2	
	Glomar Shoals	1,2	1,2	1,2			1,2	1,2		1,2						1,2				1,2		1,2		1,2	1,2	1,2		1,2				1,2	2	
	Rowley Shoals (including	1,2	1,2	1,2			1,2	1,2		1,2						1,2				1,2		1,2		1,2	1,2	1,2		1,2				1,2		

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

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 reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and interesting 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)
		Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Hydrocarbon contact and fate (Condensate/Crude/marine diesel)			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities / Habitats								Protected Species									Other Species										
	Mermaid Reef)																																	
Islands	Montebello Islands (including State Marine Park)	1,2	1,2	1,2	1,2	1,2	1,2	1,2				1,2		1,2	1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	1
	Lowendal Islands (including State Nature Reserve)	1,2	1,2	1,2	1,2		1,2	1,2				1,2		1,2	1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2		1
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	1,2	1,2	1,2	1,2		1,2	1,2				1,2		1,2	1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2	1,2		1,2	2	1
	Muiron Islands (WHA, State Marine Park)	1,2	1,2	1,2	1,2		1,2	1,2		1,2		1,2		1,2	1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2			1,2	1,2			1,2	2	
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	1,2	1,2		1,2		1,2		1,2			1,2		1,2		1,2	1,2		1,2	1,2		1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	
	Pilbara Islands	2	2		2		2		2			2		2		2	2		2	2		2	2	2	2	2		2	2			2		

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 (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 reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and interesting 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)
	– Northern Island Group (Sandy Island Passage Islands – State nature reserves)																																	
	Abrolhos Islands	1	1	1	1	1	1	1				1		1	1	1		1	1	1		1	1	1	1	1		1	1			1		
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2		1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	
	Shark Bay – Open Ocean Coast	1,2	1,2	1,2	1,2		1,2	1,2			1,2	1,2		1,2		1,2	1,2		1,2	1,2		1,2	1,2	1,2	1,2	1,2		1,2	1,2			1,2	2	
	Shark Bay WHA	1,2	1,2	1,2	1,2	1,2	1,2					1,2		1,2	1,2	1,2	1,2		1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2			1,2		

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 (**Section 4.3.4**). 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 (**Section 4.3.4**), 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 non-persistent nature of the hydrocarbons and the relatively small floating hydrocarbon ZoC, the area where potential impacts from inhalation may occur is 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), and long-term population level impacts to killer whales have been linked to the Exxon Valdez tanker spill (Matkin et al. 2008). It is worth noting that the Deepwater Horizon and Exxon Valdez spills, two well-studied large-scale hydrocarbon releases, were both crude oil spills. Crude oil is much more persistent in the environment than condensate that may be released during the Petroleum Activities Program, and also more amenable to the formation of surface slicks, which cetaceans may be exposed to when breathing. Geraci (1988) has identified behavioural disturbance (i.e. avoiding spilled hydrocarbons) in some instances for several species of cetacean suggesting that cetaceans have the ability to detect and avoid surface slicks. However, observations during spills have recorded larger whales (both mysticetes and odontocetes) and smaller delphinids traveling through and feeding in oil slicks. During the Deepwater Horizon spill cetaceans were routinely seems 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 (**Table 12-16** for the list of receptor locations important for cetaceans). Physical contact with hydrocarbons to these species is likely to have biological consequences however it is unlikely to affect an entire population and not predicted to impact on the overall population viability. Given the nature of the hydrocarbon, it is expected to weather rapidly and remain entrained in the water column; cetaceans that may interact with spilled hydrocarbons are most likely to be subject to physical impacts. Given cetaceans maintain thick skin and blubber, external exposure to hydrocarbons may result in irritation to skin and eyes. Entrained hydrocarbons may also be ingested, particularly by baleen whales which feed by filtering large volumes of water. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) may have a higher potential to cause toxic effects when ingested, while weathered hydrocarbons are considered to be less likely to result in toxic effects. Pygmy blue whales and humpback whales are known to migrate seasonally through the wider ZoC, although the migration BIAs in the region for both species do not overlap the 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 to August or October to January would coincide with pygmy blue whale migration. Double et al. (2014) suggest that pygmy blue whales migrate in offshore waters west of the Operational Area in approximately 200–1000 m of water. Both pygmy blue and humpback whales are baleen whales, and hence, are most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is low level and opportunistic, with most feeding for both species in the Southern Ocean. As such, the risk of ingestion of hydrocarbons is low. Migrations of both pygmy blue whales and humpback whales are protracted

	through time and space (i.e. the whole population will not be within the ZoC), and as such, a spill from the loss of well 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 result in a disruption to 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 on the overall population viability of cetaceans given the global distribution of these species.
	Pinnipeds Australian sea lions are found on and around the Abrolhos Islands, distant from the Operational Area but within the wider ZoC (**Section 4.3.4**, **Table 12-16**). Given the considerable distance from the Operational Area to these receptors and the lengthy time for entrained hydrocarbons to contact (minimum 86 days for the Abrolhos Islands), entrained hydrocarbons that do reach this area are likely to be heavily weathered and are expected to have minor or no impacts on sea lions.

	Marine Turtles 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). Given the non-persistent nature of the hydrocarbons and the relatively small floating hydrocarbon ZoC, the area where potential impacts from inhalation may occur is localised around the release location. Contact with entrained hydrocarbons can result in hydrocarbon adherence to body surfaces (Gagnon and Rawson 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (Gagnon and Rawson 2010). Given the hydrocarbon is expected to weather rapidly when released to the environment, relatively fresh entrained hydrocarbons (which are typically relatively close to the release location) are considered to have the greatest potential for impact. Due to the absence of potential nesting habitat and location offshore, the Operational Area is unlikely to represent important habitat for marine turtles. It is, however, acknowledged that marine turtles may be present foraging within the ZoC, and the ZoC would overlap with the BIA's identified in **Section** Error! Reference source not found., in particular, the internesting BIAs for flatback turtles which extend for ~80 km from known nesting locations. However, it is noted that the Petroleum Activities Program will coincide with nesting season for marine turtles in the region. In the event of a loss of well containment, there is potential that surface, entrained and dissolved hydrocarbons exceeding environmental impact threshold concentrations will be present in offshore waters. Therefore, a hydrocarbon spill may disrupt a portion of the population; however, there is no threat to overall population viability given the non-persistent nature of predicted hydrocarbons. Potential impacts to nesting and internesting marine turtles are discussed in the *Mainland and Islands (nearshore)* impacts discussion.
	Seasnakes Impacts to seasnakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles and may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation 2011a). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. In general, seasnakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths <100 m; see Submerged Shoals below). It is acknowledged that seasnakes will be present in the Operational Area and wider ZoC (refer to **Table 12-16**), however, their abundance is not expected to be high in the deep water and offshore environment. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population but there is not considered to be a threat to overall population viability given the non-persistent nature of hydrocarbons predicted.
	Sharks and Rays Hydrocarbon contact may affect whale sharks through ingestion (entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks may transit offshore open waters when migrating to and from Ningaloo Reef, where they aggregate for feeding from March to July. A whale shark foraging BIAs overlaps the Operational Area, and a foraging (high prey density) BIA lies approximately 276 km south-west of the Operational Area (off the Ningaloo Coast and within the wider ZoC). Therefore, individual whale sharks that have direct contact with hydrocarbons within the spill affected area may be impacted. Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs either through direct contact or via the food chain (consumption of prey). As gill breathing organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons (entering the body via the gills) and entrained hydrocarbons (coating of the gills

	inhibiting gas exchange). In the offshore environment, it is probable that pelagic shark species are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Therefore, any impact on sharks and rays is predicted to be minor and localised.
	Seabirds and Migratory Shorebirds Seabirds and migratory birds are particularly vulnerable to contact with floating hydrocarbons, which may mat feathers. This may lead to hypothermia from loss of insulation and ingestion of hydrocarbons when preening to remove hydrocarbons; both impacts may result in mortality (Hassan and Javed 2011). The credible loss of well containment scenarios result in a relatively small floating hydrocarbon ZoC centered around the release location; hence the potential for seabird exposure to floating hydrocarbons is considered to be low. Migratory shorebirds are unlikely to interact with spilled hydrocarbons; refer to the sections on Islands and Mainland Coast below for a discussion on the potential impacts to migratory shorebirds. Offshore waters are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat, which includes the numerous islands along the Pilbara coast. There are a number of BIAs for seabirds and migratory shorebirds that overlap with the wider ZoC. Given the relatively low likelihood of encounters between seabirds and floating hydrocarbons, impacts to seabirds in offshore waters are expected to consist of ecosystem-scale effects, such as reduced prey abundance. Impacts from a loss of well containment to prey such as small pelagic fish (prey for the birds) are not expected to be significant, hence subsequent impacts to a significant portion of seabirds are not expected.
Submerged Shoals and Banks[11]	**Marine Turtles** There is the potential for marine turtles to be present at submerged shoals such as Rankin Bank, Glomar Shoals and Rowley Shoals. These shoals and banks may, at times, be foraging habitat for marine turtles, given the coral and filter feeding biota associated with these areas. However, these areas are not known foraging locations and satellite tracking of individual green turtles in the nearshore environment of the NWS. Tagging studies 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 Rankin Bank, Glomar Shoals and Rowley Shoals. The potential impacts of exposure are as discussed previously in Offshore – Seasnakes. A hydrocarbon spill may have a minor disruption to a portion of the population but there is no threat to overall population viability. 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 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 and Glomar Shoals. Note, Rankin Bank is in close proximity to the Operational Area (approximately 3.5 km at the closest point and approximately 30 km away from the GWA platform) and the minimum time to contact above entrained impact thresholds from the modelling studies is < 1 day. Sharks and rays present at Rankin Bank may be exposed to fresh, unweathered hydrocarbons, which may have greater potential for toxic impacts. Pelagic sharks and rays are expected to move away from areas affected by spilled hydrocarbons. Impacts to such species are expected to be limited to behavioural responses/displacement. Shark and ray species that have associations with submerged shoals and oceanic atolls may not move in response to such habitat being contacted by spilled hydrocarbons. Such species may be more susceptible to a reduction in habitat quality resulting from a hydrocarbon spill. Impacts to sharks and rays at Rankin Bank 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.

[11] 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.

<table>
<tr><td rowspan="4">Islands and Mainland (nearshore waters)</td><td>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.</td></tr>
<tr><td>Cetaceans and Dugongs
In addition to a number of whale species that may occur in nearshore waters (such as spotted bottlenose dolphins, Indo-Pacific humpback dolphins and snubfin dolphins, refer to Section 4.3.4 for the full list of MNES 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 (see Table 12-16) which may be potentially impacted by surface, entrained and dissolved hydrocarbons exceeding threshold concentrations in the event of a loss of well containment. The loss of well containment scenarios ZoCs for entrained and dissolved hydrocarbons extends past Shark Bay. This area is a known humpback whale resting area during their annual southern migration and therefore, humpbacks moving into these aggregations areas may be exposed to hydrocarbons above thresholds levels. Shark Bay is also known as critical dugong habitat. Hydrocarbons reaching the Shark Bay region are expected to be highly weathered (minimum time to entrained contact for Shark Bay WHA is 43.6 days) and only contact the outer reaches of the Shark Bay WHA (i.e. beyond known dugong habitat).
The potential impacts of exposure are as discussed previously in Offshore – Cetaceans. However, nearshore populations of cetaceans and dugongs are known to exhibit site fidelity and are often resident populations. Therefore, avoidance behaviour may have greater impacts to population functioning. Nearshore dolphin species (e.g. spotted bottlenose dolphins) may exhibit higher site fidelity than oceanic species although Geraci (1988) observed relatively little impacts beyond behavioural disturbance. Additional potential environment impacts may also include the potential for dugongs to ingest hydrocarbons when feeding on oiled seagrass stands or indirect impacts to dugongs due to loss of this food source due to dieback in worse affected areas.
Therefore, a hydrocarbon spill may have an impact on feeding habitats and result in a disruption to a significant portion of the local population but due to the non-persistent nature of the hydrocarbon it is not predicted to result in impacts on overall population viability of either dugongs or coastal cetaceans.</td></tr>
<tr><td>Marine Turtles
Several marine turtle species utilise nearshore waters and shorelines for foraging and breeding (including internesting), with significant nesting beaches along the mainland coast and islands in potentially impacted locations such as the Ningaloo Coast, Muiron Islands, Montebello / Barrow / Lowendal Islands group, Pilbara Islands (Northern and Southern Island Groups) and Shark Bay. There are distinct breeding seasons. The nearshore waters of these turtle habitat areas may be exposed to entrained or dissolved hydrocarbons exceeding threshold concentrations, and accumulated hydrocarbons above threshold concentrations.
The potential impacts of exposure are as discussed previously in Offshore – Marine Turtles. In the nearshore environment, turtles can ingest hydrocarbons when feeding or can be indirectly affected by loss of food source (e.g. seagrass due to dieback from hydrocarbon exposure) (Gagnon and Rawson 2010). In addition, hydrocarbon exposure can impact on turtles during the breeding season at nesting beaches. Accumulated hydrocarbons above impact thresholds were identified as potentially occurring at Barrow Island, the Montebello Islands and Lowendal Islands. 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. In the event that accumulated hydrocarbons or entrained hydrocarbons reach the shoreline or internesting coastal waters (refer to Table 12-16 for receptor locations), there is the potential for impacts to turtles utilising the affected area.
During the breeding season, turtle aggregations near nesting beaches within the wider ZoC are most vulnerable due to greater turtle densities and potential impacts may occur at the population level and may impact on overall population viability of some marine turtle species. However, given the volatile nature of the hydrocarbons and low levels of shoreline accumulation predicted, population level impacts will not occur.</td></tr>
<tr><td>Sharks and Rays
Whale sharks and manta rays are known to frequent the Ningaloo Reef system and the Muiron Islands (forming feeding aggregations in late summer/autumn). Whale sharks and manta rays generally transit along the nearshore coastline and are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic</td></tr>
</table>

	organisms (Jarman and Wilson 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive sub-surface ram-feeding and active surface feeding (Taylor 2007). Passive feeding consists of swimming slowly at the surface with the mouth wide open. During active feeding, sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor 2007). These feeding methods would result in the potential for individuals that are present in worse affected spill areas to ingest potentially toxic amounts of entrained or dissolved aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect their endocrine and immune system in the longer term. The presence of hydrocarbons may cause displacement of whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are planktonic organisms which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If the spill event were to occur during the spawning season, this important food supply (in worse spill affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by the whale shark may also result in long term impacts as a result of bioaccumulation. There is the potential for other resident shark and ray (e.g. sawfish species 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, although sawfish may exhibit high habitat fidelity. **Table 12-16** indicates the receptor locations predicted to be impacted from entrained and/or dissolved aromatic hydrocarbons to the benthic communities of nearshore, subtidal communities, and it is considered that there is the potential for habitat loss to occur. Shark populations displaced or no longer supported due to habitat loss would be expected to redistribute to other locations. Therefore, the consequences to resident shark and ray populations (if present) from loss of habitat, may result in a disruption to a significant portion of the population, however, it is not expected to impact on the overall viability of the population.
	Seabirds and/or Migratory Shorebirds In the event of a loss of well containment, there is the potential for seabirds, and resident/non-breeding overwintering shorebirds that use the nearshore waters for foraging and resting, to be exposed to entrained and dissolved hydrocarbons. This could result in lethal or sub-lethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in nearshore waters near their breeding colony, resulting in intensive feeding by higher seabird densities in these areas during the breeding season and making these areas particularly sensitive in the event of a spill. Pathways of biological exposure that can result in impact may occur through ingestion of contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can also lead to internal injury to sensitive membranes and organs (International Petroleum Industry Environmental Conservation Association 2004). Whether the toxicity of ingested hydrocarbons is lethal or sub-lethal will depend on the weathering stage and its inherent toxicity (note the shortest entrained hydrocarbon time to contact with a shoreline is 10.1 days (Barrow Island)). Exposure to hydrocarbons may have longer term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks, affecting survivorship and loss of adult birds. Migratory shorebirds may be exposed to stranded hydrocarbon when foraging or resting in intertidal habitats, however, direct oiling is typically restricted to relatively small portion of birds, and such oiling is typically restricted to the birds' feet. Unlike seabirds, shorebird mortality due to hypothermia from matted feathers is relatively uncommon (Henkel et al. 2012). Indirect impacts, such as reduced prey availability, may occur (Henkel et al. 2012). Seabirds typically nest above the high water mark and as such, are not likely to encounter stranded hydrocarbons. As detailed in the preceding offshore setting summary, seabirds may be exposed to floating hydrocarbons, resulting in lethal and sub-lethal impacts. Important areas for foraging seabirds and migratory shorebirds are identified in **Section 4.3.4**. Refer to **Table 12-16** 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; and • Abrolhos Islands. Therefore, a hydrocarbon spill may result in impacts on key feeding habitat and a disruption to a significant portion of the habitat, however, this is not expected to result in a threat to the overall population viability of seabirds or shorebirds.
Summary of potential impacts to other species	
Setting	**Receptor Group**
All Settings	**Pelagic and Demersal Fish** Fish mortalities are rarely observed to occur as a result of hydrocarbon spills (International Tanker Owners Pollution Federation 2011b). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water, hence individuals exposed to a spill are likely to recover (King et al. 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers Amoco Cadiz in 1978 and the Florida in 1969) have occurred in sheltered bays. Laboratory studies have shown that adult fish are able to detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after 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 PAH concentrations (Hjermann et al. 2007). While modelling of the loss of well containment indicates the potential ZoC for dissolved hydrocarbons is extensive, no time-integrated exposure metrics were modelled; given the oceanographic environment within the wider ZoC, PAH exposures in the order of weeks for pelagic fish are not considered credible. The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and to a lesser extent affects fish consuming contaminated food (Cohen et al. 2005). The liver, a major detoxification organ, appears to be the organ where anaerobic activity is most impacted, probably increasing anaerobic activity to facilitate the elimination of ingested oil from the fish (Cohen et al. 2005). Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can mechanically damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck 2011). More subtle, chronic effects on the life history of fish as a result of exposure of early life stages to hydrocarbons include disruption to complex 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 in the region has been identified as a key ecological feature, and occurs approximately 25 km west of the Operational Area. Additionally, demersal species are associated with the ancient coastline KEF (overlaps the Operational Area), Rankin Bank (approximately 3.5 km west of the Operational Area and approximately 30 km away from the GWA platform) and Glomar Shoals (approximately 44 km 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**
Oceanic Reef and Offshore Islands **Submerged Shoals**	The waters overlying the submerged Rankin Bank have the potential to be exposed to entrained and dissolved hydrocarbons above threshold concentrations (> 500 ppb) within a relatively short space of time after a loss of well containment (0.3 days). This permanently submerged habitat represents sensitive oceanic reef benthic community receptors, extending from deep depths to relatively shallow water. Given the depth of Rankin Bank, 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 also predicted to be exposed to entrained or dissolved hydrocarbons above threshold concentrations, but with longer times to contact (and hence greater potential for hydrocarbon weathering).
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 12-16**) 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 12-16**). 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 12-16** 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 12-16** 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.
Summary of potential impacts to other habitats and communities	
Setting	**Receptor Group**
Offshore	**Benthic Fauna Communities** In the event of a loss of well containment at the seabed, the stochastic spill model predicted hydrocarbons droplets would be entrained in a gas plume, transporting them to the water column and sea surface. As a result, the low sensitivity benthic communities associated with the unconsolidated, soft sediment habitat and any epifauna (filter feeders) within and outside the Operational Area are not expected to be exposure to released hydrocarbons. A localised area relating to the hydrocarbon plume at the point of release is predicted, which would result in a small area of seabed and associated epifauna and infauna exposed to hydrocarbons.
	Open Water – Productivity/Upwelling Primary production by plankton (supported by sporadic upwelling events in the offshore waters of the NWS) is an important component of the primary marine food web. Planktonic communities are generally mixed including phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton, such as crustaceans (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton). Exposure to hydrocarbons in the water column can result in changes in species composition with declines or increases in one or more species or taxonomic groups (Batten et al. 1998). Phytoplankton may also experience decreased rates of photosynthesis (Tomajka 1985). For zooplankton, direct effects of contamination may include toxicity, suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation. Impacts on plankton communities are likely to occur in areas where entrained or dissolved aromatic hydrocarbon threshold concentrations are exceeded, but communities are expected to recover relatively quickly (within weeks or months). This is due to high population turnover with copious production within short generation times that also buffers the potential for long-term (i.e. years) population declines (International Tanker Owners Pollution Federation 2011a). Therefore, any impacts are likely to be on exposed planktonic communities present in the ZoC are short-term.
Islands and Mainland (Nearshore Waters)	**Open Water – Productivity/Upwelling** Nearshore waters and adjacent offshore waters surrounding the offshore islands (e.g. Barrow and Montebello Islands) and to the west of the Ningaloo reef system are known locations of seasonal upwelling events and productivity. The seasonal productivity events are critical to krill production, which supports megafauna aggregations such as whale sharks and manta rays in the region. This has the potential to result in lethal and sub-lethal impacts to a certain portion of plankton in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. However, recovery would occur (see offshore description above). Therefore, any impacts are likely to be on exposed planktonic communities present in the ZoC and temporary in nature.
	Spawning/Nursery Areas Fish (and other commercially targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sub-lethal impacts from exposure to hydrocarbons, particularly if a spill coincides with spawning seasons or if a spill reaches nursery areas close to the shore (e.g. seagrass and mangroves) (International Tanker Owners Pollution Federation 2011b). Fish spawning (including for commercially targeted species) occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a major spill there is potential for entrained hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters including, but not limited to the Ningaloo Coast and Shark Bay. This, and the potential for possible lower concentration exposure for dissolved aromatic hydrocarbons, have the potential to result in lethal and sub-lethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Although there is the potential for spawning/nursery habitat to be impacted (e.g. mangroves and seagrass beds, discussed above), losses of fish larvae in worst affected areas are unlikely to be of major consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). This is consistent with a recent study in the Gulf of Mexico which used juvenile abundance data, from shallow-water seagrass meadows, as indices of the acute, population-level responses of young fishes to the Deepwater Horizon spill (Fodrie and Heck 2011). Results indicated that there was no change to the juvenile cohorts following the Deepwater Horizon spill. Additionally,

	there were no significant post-spill shifts in community composition and structure, nor were there changes in biodiversity measures (Fodrie and Heck 2011). Any impacts to spawning and nursery areas are expected to be minor and short term, as would flow on effects to adult fish stocks into which larvae are recruited.
	Reefs The reef communities fringing the offshore Ningaloo Coast region may be exposed to entrained hydrocarbons (> 500 ppb) and consequently exhibit lethal or sub-lethal impacts resulting in partial or total mortality of keystone sessile benthos, particularly, hard corals and thus potential community structural changes to these shallow, nearshore benthic communities may occur. In the event that these reefs are exposed to entrained hydrocarbons, impacts are expected to result in localised long-term effects.
	Filter Feeders Hydrocarbon exposure to offshore, filter-feeding communities (e.g. deep water communities of Ningaloo coast in 20–200 m) may occur depending on the depth of the entrained and dissolved aromatic hydrocarbons. See discussion above on potential impacts.
	Sandy Shores/Estuaries/Tributaries/Creeks (Including Mudflats)/Rocky Shores Shoreline exposure for the upper and lower areas differ, the shore has the potential to be exposed to dissolved or entrained hydrocarbon. Potential impacts may occur due to hydrocarbon contact with intertidal areas, including sandy shores, mudflats and rocky shores, listed in **Table 12-16**. Hydrocarbon at sandy shores is incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores. Hydrocarbon in the intertidal zone can adhere to sand particles however high tide may remove some or most of the hydrocarbon back of the sediments. Typically, hydrocarbon is only incorporated into the surface layers to a maximum of 10 cm. As described earlier, accumulated hydrocarbons ≥ 100 g/m^2 could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat (French-McCay 2009). Note that shoreline accumulation above impact thresholds was identified as potentially occurring at Barrow / Montebello / Lowendal Islands group. Given the hydrocarbons are non-persistent, long-term impacts to shores are not expected. The impact of hydrocarbon on rocky shores will be largely dependent on the incline and energy environment. On steep/vertical rock faces on wave exposed coasts there is likely to be no impact from a spill event. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of hydrocarbon (International Petroleum Industry Environmental Conservation Association 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/m^2 could coat the epifauna along rocky coasts and impact the reproductive capacity and survival. The location of rocky shores where impacts are predicted are at Barrow / Montebello / Lowendal Islands group. Intertidal mudflats are susceptible to potential impacts from hydrocarbons as they are typically low energy environments and therefore trap hydrocarbons. The extent of oiling is influenced by the neap and spring tidal cycle and seasonal highs and lows affecting mean sea level. Potential impacts to tidal flats include heavy accumulations covering the flat at low tide however it is unlikely that hydrocarbon will penetrate the water-saturated sediments. However, hydrocarbon can penetrate sediments through animal burrows and root pores. It has been demonstrated that infaunal burrows allow hydrocarbons to subsurface sediments where it can be retained for months. Potential impacts may occur due to entrained contact with shallow, subtidal and intertidal zones of the Ningaloo Coast, and shoreline accumulation at Barrow Island, Montebello Islands and the Muiron Islands. In-water toxicity of the dissolved and entrained hydrocarbons reaching these shores will determine impacts to the marine biota such as sessile barnacle species and/or mobile gastropods and crustaceans such as amphipods. Lethal and sub-lethal impacts may be expected where the entrained hydrocarbon concentration threshold is >500 ppb. Impacts may result in localised changes to the community structure of these shoreline habitats which would be expected to recover in the medium term (2-5 years).

Key Ecological Features	**Key Ecological Features** Potentially impacted by the hydrocarbon spill from a loss of well containment event are the following KEFs: • Ancient coastline at 125 m depth contour; • Continental Slope Demersal Fish Communities; • Glomar Shoals; • Exmouth Plateau; • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula; • Commonwealth waters adjacent to Ningaloo Reef; • Mermaid Reef and Commonwealth waters surrounding Rowley Shoals; and • Western demersal slope and associated fish communities. Although these KEFs are primarily defined by seabed geomorphological features, they are described to identify the potential for increased biological productivity and, therefore, ecological significance. The consequences of a hydrocarbon spill from a loss of well containment may impact the values of the KEFs affected. Potential impacts include: the contamination of sediments, impacts to benthic fauna / habitats and associated impacts to demersal fish populations and reduced biodiversity as described above and below. Most of the KEFs within the ZoC have relatively broad-scale distributions and are unlikely to be significantly impacted.
Summary of potential impacts to water quality	
Setting	***Aspect***
Offshore 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 condensate would atomise into droplets that would be transported into the water column to the surface. As a result, the extent of potential impacts to the seabed area at and surrounding the release site would be confined to a localised footprint. Marine sediment quality would be reduced as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term.
Mainland and Islands (Nearshore waters)	**Marine Sediment Quality** Entrained and dissolved hydrocarbons (at or above the defined thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines and hydrocarbons may accumulate (at or above the ecological threshold) at a range of nearshore receptors (refer to **Table 12-16**). 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 localised, temporary reduction in air quality and contribution of greenhouse gases to the global concentration of these gases in the atmosphere. Potential impacts are expected to be a minor and short-term, predominantly localised adverse effects to air quality in the area.

There is potential for human health effects for workers in the immediate vicinity of atmospheric emissions. The ambient concentrations of methane and VOCs released from diffuse sources is difficult to accurately quantify, although the behaviour and fate is predictable in open offshore environments as it is dispersed rapidly by meteorological factors such as wind and temperature. Methane and VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photo chemically-produced hydroxyl radicals.

Due to the unlikely occurrence of a loss of well containment; the temporary nature of any methane or VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment); the predicted behaviour and fate of methane and VOCs in open offshore environments; and the significant distance from the Operational Area to the nearest sensitive air shed (town of Dampier approximately 130 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 refer to **Table 12-16** may be affected by the released hydrocarbons. In the unlikely event of a major spill and entrained hydrocarbons and/or dissolved hydrocarbons may contact the identified key receptor locations of islands and mainland coastlines resulting in the actual or perceived contamination of protected areas as identified for the ZoC (refer to **Table 12-16**).

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

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

Summary of potential impacts to socio-economic values

Setting	Receptor Group
Offshore	**Fisheries – Commercial** Spill scenarios modelled are unlikely to cause significant direct impacts on the target species of Commonwealth and offshore State fisheries within the defined ZoC. Further details are provided below (impact assessment relating to spawning is discusses above under 'Summary of potential impacts to other habitats and communities'). Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it is dependent upon the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing, and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender et al. 2002). A major spill would result in the establishment of 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. Additionally, hydrocarbon can foul fishing equipment such as traps and trawl nets, requiring cleaning or replacement.
	Tourism including Recreational Activities Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with the peak in activity between April and October (Smallwood et al. 2011). Limited recreational fishing takes place in the offshore waters of the Operational Area due to the distance from shore, however fishing may take place at Rankin Bank and Glomar Shoals. Impacts on species that are recreationally fished are described above and under 'Summary of potential impacts to other species' above.

	A major loss of hydrocarbon from the Petroleum Activities Program may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for operators.
	Offshore Oil and Gas Infrastructure In the unlikely event of a major spill, surface hydrocarbons may affect production from existing petroleum facilities (platforms and FPSOs). For example, facility water intakes for cooling and fire hydrants could be shut off which could in turn lead to the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit activity support vessel access as well as tankers approaching facilities on the NWS. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and metocean conditions. Furthermore, decisions on the operation of production facilities in the event of a spill would be based primarily on health and safety considerations. The closest oil and gas operation is the NRC platform (operated by Woodside). Other nearby facilities include the Chevron-operated Wheatstone platform and the Woodside-operated Pluto platform. Operation of these facilities is likely to be affected in the event of a worst-case loss of well containment.
Mainland and Islands (Nearshore Waters)	**Fisheries – Commercial** *Nearshore Fisheries and Aquaculture:* In the unlikely event of a loss of well containment, there is the possibility that target species in some areas utilised by a number of state fisheries in nearshore waters of the Ningaloo Coast and Shark Bay, and aquarium fisheries and aquaculture activities in the nearshore waters that are within the ZoC could be affected. Targeted fish resources could experience sub-lethal stress, or in some instances, mortality depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. *Prawn Managed Fisheries:* In the event of a major spill, the modelling indicated the entrained ZoC may extend to nearshore waters closest to the mainland coasts, including the actively fished areas of the designated Shark Bay Prawn and Scallop Managed Fishery. Prawn habitat utilisation differs between species in the post-larval, juvenile and adult stages (Dall et al. 1990) and direct impacts to benthic habitat due to a major spill has the potential to impact prawn stocks. For example, juvenile banana prawns are found almost exclusively in mangrove-lined creeks, whereas juvenile tiger prawns are most abundant in areas of seagrass (Masel and Smallwood 2000). Adult prawns also inhabit coastline areas but tend to move to deeper waters to spawn. In the event of a major spill, the model predicted shallow subtidal and intertidal habitats at the Ningaloo Coast, and mangrove and seagrass habitats of the Ningaloo Coast are located within the ZoC and could be exposed to hydrocarbon concentrations above threshold concentrations, depending on the trajectory of the plume. Localised loss of juvenile prawns in worse spill affected areas is possible. Whether lethal or sub-lethal effects occur will depend on duration of exposure, hydrocarbon concentration and weathering stage of the hydrocarbon and its inherent toxicity. Furthermore, seafood consumption safety concerns and a temporary prohibition on fishing activities may lead to subsequent potential for economic impacts to affected commercial fishing operators.
	Fisheries – traditional Although no designated traditional fisheries have been identified it is recognised that Indigenous communities fish in the shallow coastal and nearshore waters of Ningaloo Reef, and therefore, may be potentially impacted if a hydrocarbon spill from a loss of well containment were to occur. Impacts would be similar to those identified for commercial fishing in the form of a potential exclusion zone and contamination/tainting of fish stocks.
	Tourism and recreation In the unlikely event of a major spill, the nearshore waters of the Ningaloo Coast could be reached by entrained hydrocarbon, depending on prevailing wind and current conditions. This location offers a number of amenities such as fishing, swimming and utilisation of beaches and surrounds have a recreational value for local residents and visitors (regional, national and international). If a major spill resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering or tides and currents remove the hydrocarbons. In the event of a major spill, tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed. There is potential for stakeholder perception that this remote environment will be contaminated over a large area and for the longer term resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill related tourism impacts and found that on average, it took 12 to 28 months to return to baseline visitor spending. There is likely to be significant impacts to the tourism industry, wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up and change in any public misconceptions regarding the spill (Oxford Economics

	2010).
	Cultural Heritage There are a number of historic shipwrecks identified in the vicinity of the Operational Area. Shipwrecks occurring in the subtidal zone will be exposed to entrained and dissolved hydrocarbons and marine life that shelter and take refuge in and around these wrecks may be affected by in-water toxicity of dispersed hydrocarbons, The consequences of such hydrocarbon exposure may include all or some of the following: 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). Entrained hydrocarbons above threshold concentrations (> 500 g/m^2) are predicted at Ningaloo Coast. It is acknowledged that the area contains numerous Indigenous sites such as burial grounds, middens and fish traps that provide a historical account of the early habitation of the area and a tangible part of the culture of local Indigenous groups. Additionally, artefacts, scatter and rock shelter are contained on Barrow and Montebello islands (no contact by surface hydrocarbons or accumulated hydrocarbons predicted for these areas). Within the wider ZoC a number of places are designated World, National and Commonwealth heritage places. These places are also covered by other designations such as WHA, marine parks, and listed shipwrecks. Potential impacts have, therefore been discussed in the sections above.

Summary of 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 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 with the following SCE technical performance standards
  - 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 so as to prevent or mitigate the effects of a MEE. Integrity will be managed with the following SCE technical performance standards
  - F06 – Safety Instrumented System
  - P10 – Wells
- Maintain environmental incident response equipment to enact the GWA First Strike Plan. Integrity will be managed in accordance with SCE Management Procedure (Section 6.1.5.2) 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 (Resource Management and Administration) Regulations 2011: Accepted WOMP
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the GWA facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

Unplanned Hydrocarbon Release: Pipeline 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
Release of hydrocarbons resulting from loss of containment of subsea flowlines and infrastructure (GWF-1, GWF-2, PoG).		X	X	X	X	X	X	B	C	0	M	LCS GP PJ RBA CV SV	Acceptable if ALARP
Release of hydrocarbons resulting from loss of export pipeline containment (IFL, including 2TL inventory).		X	X	X	X	X	X	B	B	0	M		
Description of Source of Risk													

The GWA facility is connected to the following facilities:

- North Rankin Complex (NRC) via the 23 km, 30” IFL from the GWA RESDV via the GWA SSIV with tie-in to upstream weld to the IFL / 2TL tie-in tee. There is no fail closed or actuated isolation of the GWA IFL from 2TL;
- PoG subsea production wells via the 24.2 km, 16” diameter PoG pipeline; PoG SSIV approximately 75 m from GWA and the PoG riser;
- GWF-1 subsea production wells via the 14.4 km, 16” diameter GWF-1 pipeline; GWF-1 SSIV assembly approximately 80 m from GWA and the GWF-1 riser; and
- GWF-2 subsea production wells via the 35.4 km, 16” diameter GWF-2 pipeline which ties into the GWF-1 flowline at the GWF-1 SSIV assembly.

A subsea loss of containment of these components may result in the release of large volumes of hydrocarbon inventory. Due to the potential consequence of a worst-case subsea loss of containment, this risk is considered to be a MEE (MEE- 02), with the exception of a loss of containment from PoG pipeline; the consequence of this scenario was not considered to be an MEE.

A decision type ‘B’ has been applied to this risk under the Oil and Gas UK Decision Support Framework. 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 (described in **Section 5.2**) and oil trajectory spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The pipeline, flowline and riser design includes a range of measures that specifically aid in minimising the risk of external damage; these include:

- Material selection for strength and corrosion resistant properties;
- Subsea and surface valves to isolate pipelines from the facility and vice versa;
- Subsea shutdown system closes on loss of hydraulic pressure;
- Construction and installation techniques such as stabilisation and self-burial;
- Design of subsea equipment which takes into consideration snag potential and, where practicable, is snag resistant;
- Installation of flowline low pressure alarms (set above minimum operating pressure); and
- Flowline specifications upgraded in line with changing technologies.

The potential hazard sources that could instigate a loss of containment from the GWA pipelines and risers are:

- Internal corrosion;
- External corrosion;
- Erosion (for flowlines PoG, GWF-1 and GWF-2);
- Overpressure;
- Equipment fatigue (risers and structural supports);
- Pipeline stability and free spans;
- Anchor impact / dragging; and

Loss of control of suspended load from vessel during IMR or other activities. Although anchor impact / dragging are potential hazard sources, typical commercial trawling practices are not considered credible to result in pipeline loss of containment, given structural protection frames are in place for key subsea infrastructure (e.g. manifolds) according to design risk based analysis. The GWA/GWF development area is located outside of the two demersal trawl fishing areas within proximity of the North West Shelf. Maintenance of subsea infrastructure structural protection frames are included in mechanical integrity controls set out for pipeline integrity performance standard P09-Pipeline System.

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.

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

- Loss of Structural Integrity (MEE-04);
- Loss of Marine Vessel Separation (MEE-05); and
- Loss of Control of Suspended Load from facility lifting operations (MEE-06).

Subsea Loss of Containment – Credible Scenarios

Three credible worst-case subsea loss of containment scenarios were identified:

- Scenario 3 - Flowlines (GWF-1 / GWF-2) subsea release outboard of SSIV;
- Scenario 4 - Subsea release from IFL (including 2TL inventory) downstream of SSIV but within 500 m of GWA facility; and
- Scenario 5 - Surface release from IFL (including 2TL inventory) from rupture of riser at GWA facility.

Each worst-case scenario assumes the subsea loss of the entire hydrocarbon inventory of the pipework; no additional supply of hydrocarbons to the compromised infrastructure is assumed (i.e. assumed that the ESD system has functioned correctly). The release location for Scenario 4 was based on the closest proximity to a sensitive receptor (Rankin Bank); this location is the western end of the GWF-1 pipeline (at the LPA PLET). The release location for scenarios 4 and 5 is situated at the GWA facility; this location was considered to be the most likely location for a subsea loss of containment of the IFL (due to loss of suspended load, refer to **MEE-05**). The subsea loss of containment scenarios parameters are summarised in **Table 12-17**.

Table 12-17: 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)
Scenario 3 - Flowlines (GWF-1 / GWF-2) subsea release outboard of SSIV	GWF-2 condensate	< 4 hrs	78	19° 49' 42"	115° 39' 30"	237
Scenario 4 - Subsea	GWA	< 6 hrs	131	19° 39' 8"	115° 55' 46"	8090

release from IFL (including 2TL inventory) downstream of SSIV but within 500 m of GWA facility	condensate					
Scenario 5 - Surface release from IFL (including 2TL inventory) from rupture of riser at GWA facility	GWA condensate	~6 hrs	Surface	19° 39' 8"	115° 55' 46"	7623

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in subsea system design and construction. In the company's recent history, it has not experienced any subsea integrity events that have resulted in significant environmental impacts. The GWA facility has never experienced a worst-case subsea 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 (described in **Section 5**) and hydrocarbon spill trajectory modelling. Company were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of subsea loss of containment is considered a Major Environment Event (MEE-02). The hazard associated with this MEE is hydrocarbons in subsea infrastructure (pipelines, flowlines, manifolds etc.) tied to or originating from the GWA facility.

Quantitative Spill Risk Assessment

Spill modelling of each of the subsea loss of containment credible spill scenarios was undertaken by RPS APASA, on behalf of Woodside, to determine the fate of hydrocarbon released in each scenario based on the assumptions in **Table 12-17**. 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 subsea loss containment scenarios.

Hydrocarbon Characteristics

Refer to **MEE-01** for a description of GWA condensate. GWF-2 has similar characteristics in that all the condensates have a low ashpaltene (<0.1%) and wax (~0.2-0.9%) content, meaning they are unlikely to take up water and corm a water in oil emulsion and there is a low potential for residual hydrocarbons to be found as wax in the marine environment if these condensates are spilled.

The condensates contain a low proportion (<3% by mass) of residual hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment; however, the majority of the hydrocarbons that comprise these condensates will volatilise at ambient temperatures.

GWF-2 Condensate will have a tendency to evaporate rapidly, with 82% of the spilled volume predicted to evaporate in the first 24 hours for the variable-wind case (**Figure 12-7**).

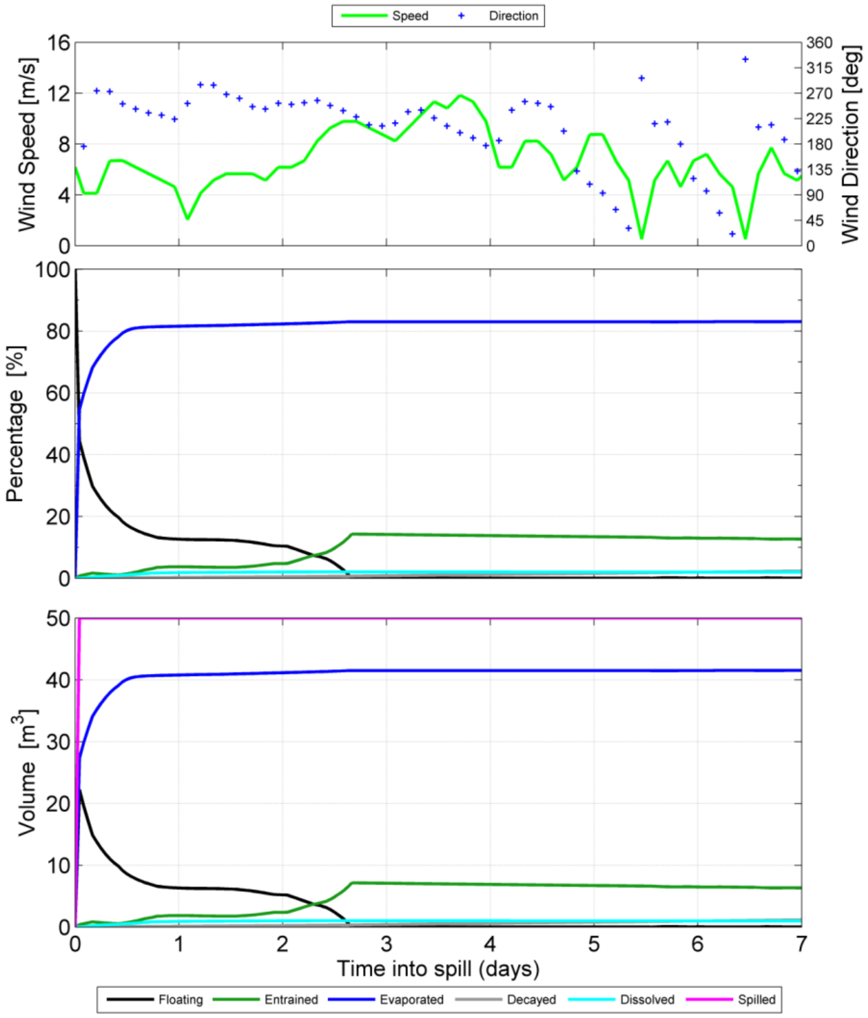

Figure 12-7: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of GWF-2 Condensate spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to variable winds (top panel) at 27 °C water

Subsea Plume Dynamics

The subsea loss of containment scenarios (scenarios 3 and 4) will result in a buoyant plume of hydrocarbons, which has been modelled using the OILMAP-Deep numerical model (summarised in **Table 12-18**).

Table 12-18: Inputs and outputs for OILMAP-Deep model for scenarios 3 and 4

	Parameter	Scenario 3	Scenario 4
Inputs	Release depth (m below sea level)	78.0	131.0
	Oil density (g/cm^3) (at 15°C)	0.791	0.738
	Oil viscosity (cP) (at 15°C)	1.175	0.529
	Oil temperature (°C)	50	25
	Gas:oil ratio (m^3/m^3) [scf/bbl]	3600 [20,211]	6066 [34,055]
	Oil flow rate (m^3/d)	237 [1491]	2191 [13,781]
	Hole diameter (m) [in]	0.350 [13.763]	0.723 [28.472]
Outputs	Plume diameter (m)	10.1	16.9
	Plume height (m above sea bed)	78.0 (surface)	131.0 (surface)

	Plume initial rise velocity (m/s)	12.8	19.8
	Plume terminal rise velocity (m/s)	10.4	16.1
Predicted oil droplet size distribution	21.4% droplets of size (µm)	18.4	5.9
	31.1% droplets of size (µm)	36.9	11.9
	24.7% droplets of size (µm)	55.3	17.8
	15.1% droplets of size (µm)	73.8	23.8
	7.7% droplets of size (µm)	92.2	29.7

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e., design, inspection and maintenance, pipeline marked on marine charts), the likelihood has been taken as 0 (Remote). The likelihood of release due to dropped object impact is also taken as 0 (Remote) because the flowlines outboard of the SSIVs are outside the drop range for lifting activities taking place on the facility.

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 numerical modelling studies undertaken by 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 to Marine Sediment, Water Quality, Air Quality, Ecosystems / Habitats, Species and Socio-Economic Environment

Zone of Consequence

Quantitative hydrocarbon spill modelling results for scenarios 3, 4 and 5 are summarized in **Table 12-19.**

Surface Hydrocarbons

Quantitative spill modelling for scenarios 3 and 4 did not indicate surface hydrocarbons at concentrations > 10 g/m^2. Hence, there are no receptors predicted to be contacted by floating hydrocarbons for these scenarios. Modelling of Scenario 5 indicated the potential for floating oil > 10 g/m^2 in the vicinity of the release location. Floating hydrocarbons above impact thresholds were not predicted to contact key surface receptor locations.

Entrained Hydrocarbons

Quantitative hydrocarbon spill modelling results for entrained hydrocarbons for scenarios 3, 4 and 5 are summarized in **Table 12-19**. Modelling results indicated a number of environmental sensitivities may be contacted by entrained hydrocarbons above impact thresholds, with time to contact ranging from 0.2 days (Rankin Bank) to 32 days (Ningaloo Coast Middle). In the event of a worst-case subsea loss of containment scenario occurring, entrained hydrocarbons at or above 500 ppb are forecast to potentially extend up to 400 km from the release site. The most likely direction of drift is south-westerly around the Ningaloo Coast, reflecting the prevailing current patterns. Results also indicate that entrained oil may also be likely to drift towards the northeast and in the offshore directions at lower probabilities.

Dissolved Hydrocarbons

Only one sensitive receptor location, Rankin Bank, was predicted by modelling to be contacted by dissolved hydrocarbon concentrations > 500 ppb. In the event of a subsea loss of containment scenario occurring, dissolved hydrocarbons at or above 500 ppb are forecast to potentially occur up to 75 km from the release site.

Accumulated Hydrocarbons

No accumulated hydrocarbons above impact thresholds were predicted by modelling for the release scenarios considered in MEE-02.

Table 12-19: 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 (WM0000PG10055394))																													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 reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and interesting 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[12]	Ningaloo CMP	4	4					4		4					4	4			4		4	4	4	4	4	4		4	4			4		
Submerged Shoals and banks	Rankin Bank	4,5	4,5	4,5			4,5	4,5		4,5						4,5				4,5		4,5		4,5	4,5	4,5		4,5				4,5		
Islands	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	4,5	4,5		4,5		4,5		4,5			4,5		4,5		4,5	4,5		4,5	4,5		4,5	4,5	4,5	4,5	4,5		4,5	4,5			4,5		
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	4	4	4	4	4	4	4		4		4	4	4	4	4	4		4	4		4	4	4	4	4		4	4			4		

[12] 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 scenarios that may arise from MEE-2 may impact upon a range of environmental receptors; refer to **Table 12-19** 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; as described above 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 pipeline, 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:
  ○ F06 – Safety Instrumented System
  ○ P09 – Pipeline Systems
  ○ P21 - Substructures
  ○ 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(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 – Safety Instrumented System
  ○ P09 – Pipeline Systems
  ○ P10 – Wells
• Maintain environmental incident response equipment to enact the GWA 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 GWA 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 topside process equipment to the marine environment and atmosphere.			X	X	X	X	X	B	C	1	M	LCS GP PJ RBA 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 hydrocarbon processing equipment on the GWA facility contains a considerable volume of hydrocarbons. The hydrocarbon inventory of this processing equipment may be released, potentially resulting in hydrocarbons being released to the marine environment. Due to the potential consequences of a worst-case topsides loss of containment, this risk is considered to be a MEE (MEE-03).

The following events could lead to loss of containment from the topsides:

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

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.

Escalation from other MEEs can also potentially lead to cause Topsides Loss of Containment:

- Loss of Structural Integrity (MEE-04);
- Loss of Marine Vessel Separation (MEE-05); and
- Loss of Control of Suspended Load from facility lifting operations (MEE-06);

GWA's diesel storage tanks (194m^3 and 149 m^3) are housed within the East and West crane pedestals and are integral into the structure which supports the crane. As such the tank structures have a low probability of failure. Diesel distribution draws from storage and a stainless steel Break Tank (0.8 m^3), and feeds the stainless steel diesel fire pump day tank (5.4 m^3), Emergency Diesel Generator (5.9 m^3) incorporated into the base frame). Manual diesel transfer occurs for day tanks for both cranes situated within the crane structure (1.6m^3 and 2m^3 respectively) and small inventories to survival craft storage tanks.

Topsides Loss of Containment – Credible Hydrocarbon Spill Scenario (Scenario numbering continuing from previous MEEs)

The following hydrocarbon inventories were considered as the worst-case topsides loss of containment scenario:

- Scenario 6 – Instantaneous release from the GWA facility of:
  - Gas and GWA Condensate: 135 m^3;
  - GWA Condensate: 403 m^3; and
  - Marine Diesel: 343 m^3.

The locations, hydrocarbon types and volumes for Scenario 6 are provided in **Table 12-20**.

Table 12-20: Summary of worst-case topsides loss of containment hydrocarbon release scenario

Scenario	Hydrocarbon	Duration (hrs)	Depth (m)	Latitude (D°M'S'' S)	Longitude (D°M'S'' E)	Total Release Volume (m^3)
Scenario 6 – Topsides loss of containment	Gas and condensate	Instantaneous	Surface	19° 39' 8"	115° 55' 46"	135
	Condensate	Instantaneous	Surface	19° 39' 8"	115° 55' 46"	403
	Marine diesel	Instantaneous	Surface	19° 39' 8"	115° 55' 46"	343

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in topsides design and construction. In the company's recent history, it has not experienced any topside integrity events that have resulted in significant releases or significant environmental impacts. The GWA facility has never experienced a worst-case topsides 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 and hydrocarbon spill trajectory modelling (**Section 5)** Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of topsides loss of containment is considered a Major Environment Event (MEE-03). The hazard associated with this MEE is hydrocarbon inventory on the GWA facility in process and non-process equipment.

Quantitative Spill Risk Assessment

Spill modelling of the diesel component of Scenario 6 was undertaken by RPS APASA, on behalf of Woodside, to determine the fate of hydrocarbon based on the assumptions in **Table 12-20**. Note that modelling of the gas and condensate components of Scenario 6 was not undertaken; the modelling used to inform Scenario 5 has been considered as a worst case analogue for these components in Scenario 6. Note the release location for Scenario 5 is consistent with Scenario 6, and the credible volumes are significantly larger.

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 from a topsides loss of containment.

Hydrocarbon Characteristics

Refer to **MEE-01** and **MEE-02** for a description of condensate characteristics.

Marine diesel is a mixture of volatile and persistent hydrocarbons with low proportions of highly volatile and residual components. 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 have a tendency 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.

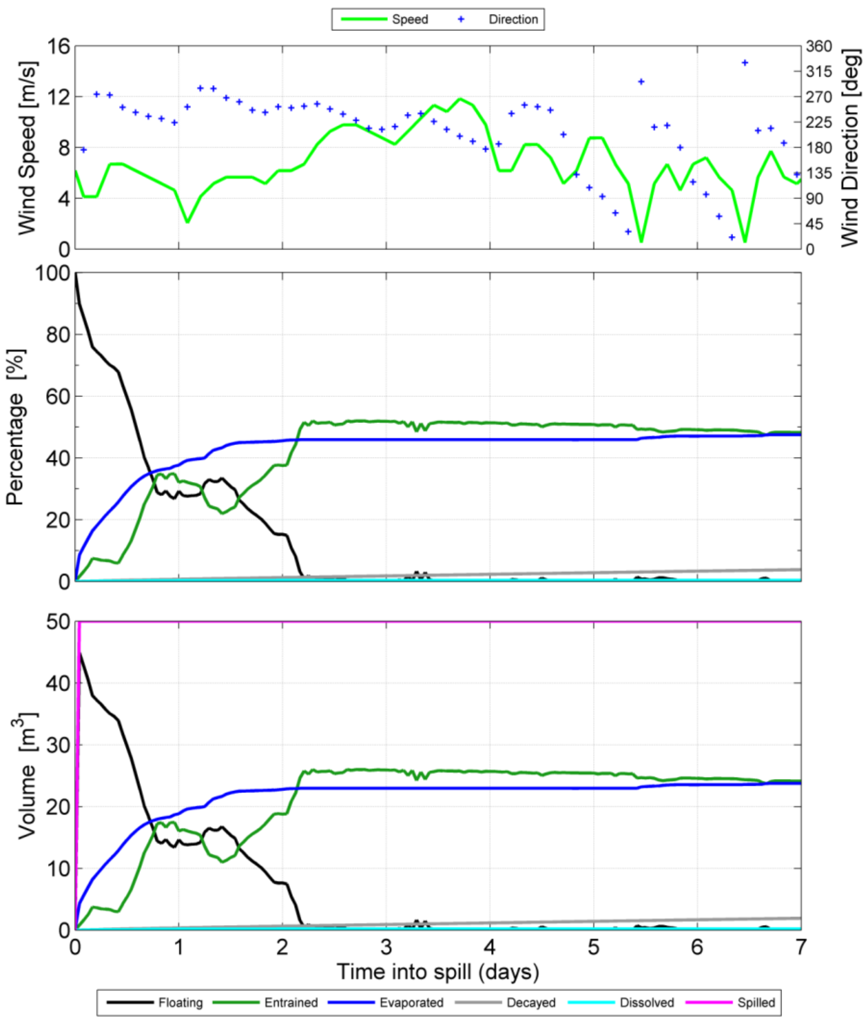

Figure 12-8: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of marine diesel spilled onto the water surface as a one-off release (50 m3 over 1 hour) and subject to variable winds (top panel) at 27 °C water temperature

Likelihood

In accordance with the Woodside Risk Matrix, a worst-case topsides loss of containment has been defined as a 'highly unlikely event as it is '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.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case topsides loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by 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*** The gas and condensate components of a worst case topsides loss of containment are not expected to result in surface hydrocarbons above impact thresholds (> 10 g/m^2). The diesel component of Scenario 6 may result in floating

hydrocarbons beyond the immediate vicinity of the release location. No contact of floating hydrocarbons above impact thresholds with key receptor locations was indicated by the modelling.

Entrained Hydrocarbons

Entrained hydrocarbons from the condensate component of a topsides release may become entrained and hence, extend beyond the vicinity of the release location. Refer to the entrained hydrocarbon description for a loss of containment from the GWA export riser (Scenario 4) for context (MEE-02); note the credible volume for a topsides loss of containment is considerably smaller and hence, the potential ZoC above entrained impacts thresholds is expected to be smaller. The diesel component of Scenario 6 has the potential to become entrained and may extend beyond the release location. No contact of entrained hydrocarbons above impact thresholds with key receptor locations was indicated by the modelling.

Dissolved Hydrocarbons

Dissolved hydrocarbons above impact thresholds from a topsides loss of containment are expected to be localised to the immediate area around the release location. Modelling of subsea loss of containment indicated dissolved hydrocarbons above impact threshold would be in the immediate vicinity of the release location. Modelling of the diesel component of Scenario 6 did not indicate dissolved hydrocarbons above impact thresholds would occur. No contact with key receptor locations above impact thresholds is expected to occur.

Accumulated Hydrocarbons

No accumulated hydrocarbons above impact thresholds were predicted by modelling for the release scenarios considered in MEE-03.

Consequence Assessment Summary

The credible worst-case hydrocarbon spill scenario that may arise from MEE-03 may impact upon the open water environment in the vicinity of the GWA platform. Hydrocarbon spill modelling of the marine diesel component of the credible worst-case scenario did not indicate contact above impact thresholds for any sensitive environmental receptors. As such, potential environmental impacts are expected to be restricted to open water sensitivities such as marine fauna; refer to **MEE-01** for a description of potential impacts to open-water sensitivities.

The credible worst-case hydrocarbon volumes that can credibly be released by MEE-03 are significantly smaller than the credible worst-case loss of well containment volumes considered in MEE-01. Additionally, the credible release durations are instantaneous rather than protracted. These considerations are pertinent when considering the potential environmental impacts described for MEE-01 in relation to MEE-03.

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
  - P08 - Piping Systems
- Maintain Safety Instrumented Systems and relief system to prevent hydrocarbon loss of containment in order to prevent 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 – Safety Instrumented System
  - F21 – Relief Systems
- 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(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:

- F06 – Safety Instrumented System
- F09 – Depressurisation (Blowdown)
- F22 – Open Hazardous Drains

- Maintain environmental incident response equipment to enact the GWA 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 GWA 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-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 platform well 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 pipeline and riser to the marine environment and atmosphere		X	X	X	X	X	X	B	B	0	M		
Hydrocarbon release from topsides equipment to the marine environment and atmosphere			X	X	X	X	X	B	C	1	M		
Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA		X	X	X	X	X	X	B	C	0	M		

Description of Source of Risk

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 tower, etc.) has been identified as a potential MEE (MEE-04). Catastrophic structural failure of the GWA facility could lead to the release of hydrocarbons from platform wells, topsides process and non-process hydrocarbon inventories, and pipeline / IFL inventories.

The following causes of structural failure of GWA were identified:

- Internal corrosion (e.g. of caissons);
- External Corrosion;
- Fatigue;
- Impact from a vessel collision (refer to MEE-05)
- Extreme weather (cyclone, high waves);
- Seismic events / seabed instability; and
- Fire / Overpressure event.

There is a possibility of platform collapse (‘slow’ or ‘rapid’) caused by the extreme loads induced by strong winds and extreme waves. Extreme weather may induce fracture of pipework due to vibration/fatigue and loosen/dislodge objects/projectiles causing impact to equipment/pipework and subsequently result in a loss of containment.

Structural damage to the platform resulting from the causes listed above could be minor, or could in the most extreme situation result in total loss of the platform. The type of structural failure considered is restricted to major structural damage e.g. catastrophic collapse of the jacket or release of hydrocarbons on or adjacent to the platform. Such events are, by definition, beyond the design basis for the platform. Structural damage can affect any area of the platform.

Loss of Structural Integrity – Credible Hydrocarbon Spill Scenario

A loss of structural integrity could result in a significant release of hydrocarbons. Hydrocarbon releases may result in a spill to the marine environment, as described in MEE-01 - Well Loss of Containment, MEE-02 - Subsea Loss of Containment and MEE-03 - Topsides Loss of Containment. In addition, vessel cargo, including diesel inventory could be spilled if the cause of the loss of platform integrity was a collision from a support vessel as per MEE-05 - Loss of Marine Vessel Separation.

Worst case hydrocarbon release scenarios for platform well loss of containment, subsea loss of containment, topsides loss of containment that could result from loss of structural integrity of the GWA platform are discussed in the relevant sections referenced above. Relevant trajectory modelling as applicable to these scenarios is also discussed in the above-mentioned sections.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in structural design and construction. The GWA facility has never experienced a worst-case loss of containment due to structural failure 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 and hydrocarbon spill trajectory modelling (**Section 5**). Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The loss of structural integrity is considered a Major Environment Event (MEE-04). The hazards associated with this MEE is hydrocarbons in platform wells, pipelines, process and non-process inventories and potentially vessels, wellheads, and the GWA facility structure itself.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon scenarios 1, 3, 4, 5 and 6 are considered to apply to a loss of structural integrity (MEE-4). Refer to the **MEE-01** (Scenario 1), **MEE-02** (Scenarios 3,4 and 5) and **MEE-03** (Scenario 6) for a discussion of these credible worst-case spill scenarios.

Likelihood

In accordance with the Woodside Risk Matrix, the following likelihoods have been assigned to the sources of risk:

- Hydrocarbon release from platform well to the marine environment and atmosphere / Hydrocarbon release from topsides equipment to the marine environment and atmosphere
    - '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
- Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA
    - 'remote' event as it is 'unheard of on the industry' (experience based likelihood) and aligns with a frequency of a '1 in 100,000 to 1 in 1,000,000 year' event

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon and the potential seabed disturbance footprint from the GWA facility were considered during the impact assessment for a worst-case loss of structural integrity. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by 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

As discussed under Description of Source of Risk, the potential impacts from hydrocarbon release caused by a loss of structural integrity are those which would result from:

- Well Loss of Containment (MEE-01);
- Subsea Loss of Containment (MEE-02);
- Topsides Loss of Containment (MEE-03); and
- Loss of Marine Vessel Separation (MEE-05).

The potential impacts are therefore discussed in the above mentioned sections.

Seabed Disturbance

In the event of loss of structural integrity there is the potential for collapse of the platform leading to an incremental

increase of the facility's footprint on the seabed. The potential area that would be affected can conservatively be defined as the existing GWA facility footprint plus 100 m in all directions, that is approximately 300 m by 350 m (0.105 km^2). The benthic habitats surrounding the GWA facility have been subject to historical disturbance (e.g. GWA construction, discharge of drill cuttings) and are considered to be of low ecological value (although it is acknowledged that the GWA facility provides artificial hard substrate, which has formed the basis of relatively high biodiversity communities when compared to the surrounding seabed). The physical disturbance to the seabed resulting from the collapse of the GWA facility would be localised, but result in long-term disturbance to benthic communities. The GWA platform could act as a source of environmental contaminants due to material onboard the platform (e.g. chemical / hydrocarbon inventories, corrosion of structural materials, debris etc.). The potential for contamination will diminish over time as the structure degrades. Depending on the nature of the loss of structural integrity, complete or partial salvage of the GWA platform may not be feasible. Any structures not able to be recovered will be left on the seabed indefinitely. These structures are expected to be colonized by marine organisms, and a reef habitat will develop over time on the structures.
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 – Substructures
  - P21 – Topsides / Surface Structures
- 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:
  - F27 – Control of Ignition Sources
  - F14 – Fire Water System
  - F15 – Manual Fire Fighting Equipment
  - F19 – Gaseous Extinguishing System
  - F20 – Passive Fire and Explosion Protection
- Maintain environmental incident response equipment to enact the GWA 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 GWA 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-05)

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 platform well 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 pipeline and riser to the marine environment and atmosphere		X	X	X	X	X	X	B	B	0	M		
Hydrocarbon release from topsides equipment to the marine environment and atmosphere			X	X	X	X	X	B	C	1	M		
Marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA.		X	X	X	X	X	X	B	C	0	M		

Description of Source of Risk

A loss of marine vessel separation between a vessel and the GWA facility may result in a loss of hydrocarbon containment from the GWA facility and / or the release of fuel from the vessel. A vessel collision with the GWA facility has been identified as a potential MEE (MEE-05). Vessel collisions can arise from:

- Visiting vessel collisions associated with platform support vessels - ships which are visiting the platform can accidentally collide with the platform during approach to, or manoeuvring alongside, the platform; and
- Errant passing vessel collision - ships which are not visiting the platform (i.e. passing vessels) can, for one reason or another, move off-course and collide with the platform.

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 the GWA facility. 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 platform operations. These errors could be worsened by the following:

- Vessel station keeping failures; or
- Vessel operations in adverse weather conditions;

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.

A loss of marine vessel separation between a vessel and the GWA facility may result in a loss of hydrocarbon containment from the GWA facility and / or the release of fuel from the vessel. A vessel collision with the GWA facility has been identified as a potential MEE (MEE-05). Vessel collisions can arise from:

- Visiting vessel collisions associated with platform support vessels - ships which are visiting the platform can accidentally collide with the platform during approach to, or manoeuvring alongside, the platform; and
- Errant passing vessel collision - ships which are not visiting the platform (i.e. passing vessels) can, for one reason or another, move off-course and collide with the platform.

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 the GWA facility. 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 platform operations. These errors could be worsened by the following:

- Vessel station keeping failures; or
- Vessel operations in adverse weather conditions;

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.

Errant Passing Vessels

Errant passing vessels are defined as third-party vessels that enter the platform's 500 m Petroleum Safety Zone, but do not call at GWA or other installations (i.e. not platform or subsea support vessels). The collision can be powered or drifting. Either has the potential to cause significant damage to GWA.

The causes of errant passing vessel collisions include:

- failure of propulsion or steering systems;
- adverse weather conditions resulting in poor visibility;
- rough seas; and
- human error.

Woodside implement a range of control measures to mitigate the risk of errant vessel collision.

In addition to the potential for large hydrocarbon releases following impact by a vessel with the GWA structure, powered collisions from large passing vessels or tankers could have sufficient impact energy to breach both skins of the vessel to the extent that there is a loss of containment of cargo or fuel oil with the potential for significant loss of inventory and consequent environmental impact.

Loss of Vessel Separation – Credible Hydrocarbon Spill Scenario

The loss of marine vessel separation is considered a Major Environment Event (MEE-05). The hazards associated with this MEE is hydrocarbons in platform wells, pipelines, process and non-process inventories and potentially vessels, wellheads, and fuel onboard platform support vessels. 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-01 - Well Loss of Containment, MEE-02 - Subsea Loss of Containment and MEE-03 - Topsides Loss of Containment. In addition, vessel cargo, including diesel inventory, could be spilled if the cause of the loss of platform integrity was a collision from a support vessel.

Worst case hydrocarbon release scenarios for platform loss of well containment (MEE-01), subsea loss of containment (MEE-02) and topsides loss of containment (MEE-03) 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 above.

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:

- 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 highly unlikely. 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 a platform 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 platform support vessels typically operate in the GWA Operational Area, 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, 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 platform 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 content of a 105 m^3 tank.

The marine diesel component of the topsides loss of containment MEE described in **MEE-03** is considered to be a suitable surrogate for the risk assessment of a 105 m^3 release of marine diesel from a vessel as the volume is considerably larger (343 m^3).

Decision Type, Risk Analysis and ALARP Tools

Woodside has not experienced any loss of marine vessel separation events that have resulted in significant environmental impacts. The GWA facility has never experienced a worst-case loss of containment due to 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 and hydrocarbon spill trajectory modelling (**Section 5**). Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon spill scenarios 1, 3, 5 and 6 are considered to apply to a loss of structural integrity (MEE-4). Refer to the **MEE_01** (Scenario 1), **MEE-02** (Scenarios 3,4 and 5) and **MEE-03** (Scenario 6) for a discussion of these credible worst-case spill scenarios.

Likelihood

In accordance with the Woodside Risk Matrix, a likelihood of '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' has been assigned to each of the following events:

- hydrocarbon release from platform well to the marine environment and atmosphere;
- hydrocarbon release from pipeline and riser to the marine environment and atmosphere; and
- hydrocarbon release from topsides equipment to the marine environment and atmosphere;

In addition, a 'Remote' likelihood with a frequency of a '1 in 100,000 to 1 in 1,000,000 year' has been assigned for:

- marine environment footprint and associated hydrocarbon and chemical release associated with structural collapse of GWA platform.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon from the GWA facility and platform support vessels were considered during the impact assessment for a worst-case loss of marine vessel separation. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by 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

As discussed under Description of Source of Risk, the potential impacts from hydrocarbon release caused by a loss of structural integrity are those which would result from:

- Well Loss of Containment (MEE-01);
- Subsea Loss of Containment (MEE-02); and
- Topsides Loss of Containment (MEE-03).

The potential impacts are therefore discussed in the above mentioned sections.

The credible worst-case diesel spill from a vessel (105 m^3) is considerably smaller than the credible worst-case diesel spill scenario identified due to a topsides loss of containment (343 m^3) (MEE03). A credible worst-case diesel spill from a vessel is not expected to contact sensitive environmental receptors above impact thresholds given modelling of the larger worst-case diesel release from a topsides loss of containment did not indicate contact nearshore environmental receptors above impact thresholds, and was limited to open water sensitives and marine fauna.

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:
    - P34 Collision Prevention Systems
- 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 environmental incident response equipment to enact the GWA 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 GWA 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 from Platform (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 from pipeline and riser to the marine environment and atmosphere.		X	X	X	X	X	X	B	C	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	X	B	C	1	M		

Description of Source of Risk

Lifting activities on GWA can take place from one of two platform cranes between supply vessels and laydown areas, or between laydown areas. Lifting operations performed using the platform or visiting vessel cranes could potentially lead to dropped objects impacting assets (topsides equipment, subsea infrastructures) inside the GWA 500 m Petroleum Safety Zone, potentially leading to a hydrocarbon loss of containment from topsides and subsea infrastructure. Loss of suspended load has been identified as a MEE (MEE-06). A loss of suspended load may arise from:

- lifting equipment failure; and
- facility lifting operations.

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 Suspended Load – Credible Hydrocarbon Spill Scenario

The identified outcome of this MEE is a loss of containment of hydrocarbons due to impact of a dropped object on topsides equipment or subsea pipelines resulting in a release of the hydrocarbon inventory to the atmosphere or the marine environment; refer to MEE-02 - Subsea Loss of Containment and MEE-03 - Topsides Loss of Containment**.** for a description of these credible loss of containment scenarios. It is not considered credible that loss of control of suspended load during topsides lifting operations will result in a MEE from the platform wells or IFL pipeline loss of containment.

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 hydrocarbon spill trajectory modelling. Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of subsea loss of containment is considered a Major Environment Event (MEE-02). The hazard associated with this MEE is hydrocarbons in subsea infrastructure (flowlines, manifolds etc.) tied to, or originating from, the GWA facility.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon Scenarios 3 (MEE-02) and 5 and 6 (MEE-03) are considered to apply to the potential loss of containment that may occur in the event of a loss of a suspended load. Refer to **MEE-02** (Scenarios 5) and MEE-03 (Scenario 6) for a discussion of these credible worst-case spill scenarios.

Likelihood

In accordance with the Woodside Risk Matrix, a likelihood of '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' has been assigned to each of the following events:

- hydrocarbon release from pipeline and riser to the marine environment and atmosphere; and
- hydrocarbon release from topsides equipment to the marine environment and atmosphere.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case loss of suspended load. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by 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

Zone of Consequence

As discussed under Description of Source of Risk, the potential impacts from hydrocarbon release caused by a loss of structural integrity are those which would result from:

- Subsea Loss of Containment (MEE-02); and
- Topsides Loss of Containment (MEE-03).

The potential impacts are therefore discussed in the above mentioned sections.

Summary of Control Measures

- Maintain platform lifting equipment to prevent platform lifting equipment failure or dropped/swinging loads that could result in 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:
    - 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:
    - P07 - Substructures
    - P21 - Topsides / Surface Structures
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the GWA facility
- Incident reports are raised for unplanned releases within event reporting system.
- Mitigation – hydrocarbon spill response (Appendix B)

MEE Common Cause Event failure mechanisms: SCE Failure CCE-01 and Human Error CCE-02

This section presents common mode failure causes and controls applicable across MEEs which are detailed within sections above. Controls, Environmental Performance Standards and Measurement Criteria presented within this section are also considered relevant to MEE01 to MEE06.

GWA: 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:
  o F06 – Safety Instrumented System
• 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:
  o P01 – Pressure Vessels
  o P02 – Heat Exchanger
  o P03 – Rotating Equipment
  o P07 – Topsides / Surface Structures
  o P08 – Piping Systems
  o P09 – Pipeline Systems
  o P10 – Wells
  o 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:
  o 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:
  o E02 – Safety Critical Buildings
• Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: Accepted Safety Case for the GWA facility	

GOODWYN ALPHA: Major Environmental Event Datasheet

MEE Number	ALL
Hazard Description	Generic Human Errors – Degradation Factors
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 barriers in place to protect against MEEs. These 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. Human Errors are managed solely via the WMS (no SCEs). Applicable Management System Procedures are detailed in the Implementation Strategy.	

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 12-21: Analysis of risks and impacts

	Environmental Value						
	Soil& Groundwater	Marine Sediment Quality	Water Quality	Air Quality	Ecosystems/ Habitat	Species	Socio-Economic
Monitor and evaluate		X	X		X	X	
Source control		X	X		X	X	X
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 anchoring

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.

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.

Vegetation cutting

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.

Implementing a Shoreline Clean-up operations will result in the generation of the following waste streams that will require management and disposal:

- Semi-solids/solids (oily solids), collected during shoreline clean-up operations
- PPE
- Oiled debris (seaweed, drift wood etc.)

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 are not released back into a contaminated environment.

Treatment of impacts and risks from implementing response strategies

In 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 anchoring and access in the nearshore environment

- 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

Presence of personnel on the shoreline

- oversight by trained personnel who are aware of the risks
- trained unit leaders 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.
- Vehicular access will be restricted on dunes, turtle nesting beaches and in mangroves.

Vegetation cutting

- Limiting vegetation removal to only that vegetation that has been moderately or heavily oiled
- Minimising the mixing of clean and oiled sediment and shoreline substrates.

Additional stress or injury caused to wildlife

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

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

Relevant Stakeholder feedback for the Petroleum Activities Program

Organisation	Method	Feedback	Woodside assessment	Woodside's response
Department of Industry, Innovation and Science	Email with fact sheet	**Date:** 16 June 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 Environment and Energy	Email with fact sheet	**Date:** 26 March 2018 **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:** 16 June 2017 **Feedback summary:** The Department acknowledged that Woodside will revise and submit an EP for the operation of the GWA. 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.
AMSA (maritime safety)	Email with fact sheet	**Date:** 16 June 2017 **Feedback summary:** The Authority recommended that Woodside consider marking the Goodwyn Alpha platform with an Automatic Information System (AIS). The Authority advised that AIS can be used to assist with positive identification by transiting and service vessels. It may also assist with monitoring vessel traffic in the vicinity, including potential and real incursions into the Petroleum Safety Zones. The Authority provided a link to further guidelines on AIS.	The stakeholder raised no claims or objections but provided advice on AIS opportunities Woodside provided an email response on 9 August 2017, acknowledging the Authority's feedback. Woodside advised that it is currently assessing future upgrade options for maritime situation awareness and collision prevent systems across Woodside facilities. This includes radar and AIS. Woodside thanked the Authority for providing information on AIS.	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside assessment	Woodside's response
	Emailed draft First Strike Plan	**Date:** 26 October 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 Hydrographic Service	Email with fact sheet	**Date:** 19 June 2017 **Feedback summary:** The Service acknowledged receipt of Woodside's email.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Department of Primary Industries and Regional Development (*formerly Department of Fisheries (Western Australia*))	Email with fact sheet and fishery map	**Date:** 29 September 2017 **Feedback summary:** The department thanked Woodside for the opportunity to comment and acknowledged their understanding that no major changes are proposed to facility operations. The department advised that they have no comments at this time.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
Commonwealth fisheries Western Tuna and Billfish	Email with fact sheet and fishery map	**Date:** 16 June 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 Onslow Prawn	Letter with fact sheet and fishery map	**Date:** 26 June 2017 **Feedback summary:** No response at the time of submission.	Woodside will accept and assess feedback from stakeholder post EP submission to NOPSEMA. Woodside has reviewed comments provided for previous petroleum activities in this Licence. The following accepted EPs did not receive feedback from Western Australian fisheries: • Greater Western Flank Phase 1 Drilling and Completions • Greater Western Flank	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside assessment	Woodside's response
			Phase 1 Project Pipeline Installation • Greater Western Flank 2 Geophysical and Geotechnical Surveys • Greater Western Flank Phase 2 Tieback Feedback was received from a Trap Fishery license holder during consultation for the accepted Greater Western Flank Phase 1 Gas Development Subsea Installation and Commissioning EP. Woodside did follow up with this license holder but no contact was returned.	
Department of Defence	Email with fact sheet and map of defence zones	**Date:** 16 June 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:** 27 June 2017 **Feedback summary:** The Department acknowledged receipt of email.	The stakeholder raised no claims or objections.	**Response/Action:** No further action required.
	Emailed draft First Strike Plan	**Date:** 26 October 2017 **Feedback summary:** The Department acknowledged receipt of email.	The stakeholder raised no claims or objections, but requested additional information.	**Response/Action:** No further action required.
		Date: 22 November 2017 **Feedback summary:** • The Department offered commentary on the first strike plan, including: • Ensure consistent revision	The stakeholder raised no claims or objections, but requested additional information. Woodside provided an email response on 5 December:	**Response/Action:** No further action required.

Organisation	Method	Feedback	Woodside assessment	Woodside's response
		numbers. • The FSP refers to the Jan 2017 version of the Offshore Petroleum Industry Guidance Note. • Provide further detail on the ZOC • Which tactical response plans have been developed for the ZOC. Have they been sent to DoT? Have regional operations centres been identified.	December: • Confirmed that the version submitted to DOT was revision B of the FSP • Confirmed Woodside are referring to the latest version of the IGN. FSP updated to reflect this and re-sent. • Provided further detail on the extent of the ZOC • Confirmed and sent all of the tactical response plans within the ZOC. • Confirmed the Forward Operating Base would be established in Dampier at Woodside King Supply Base.	
Commonwealth Fisheries Association	Email with fact sheet and fishery map	**Date:** 16 June 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:** 16 June 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.

Feedback from Interested Stakeholders on the Petroleum Activities Program

Organisation	Method	Feedback	Woodside assessment	Woodside's response
AFMA	Email with fact sheet and fishery map	**Date:** 16 June 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:** 16 June 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.
City of Karratha	Email with fact sheet	**Date:** 16 June 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:** 16 June 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:** 16 June 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.
APPEA	Email with fact sheet	**Date:** 16 June 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.
Conservation Council of Western Australia	Email with fact sheet	**Date:** 26 June 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.

Organisation	Method	Feedback	Woodside assessment	Woodside's response
Pilbara Port Authority	Email with fact sheet	**Date:** 26 June 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:** 26 June 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:** 26 June 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:** 26 June 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.
Wilderness Society	Email with fact sheet	**Date:** 26 June 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:** 26 June 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 (formerly Department of Parks and Wildlife	Email with fact sheet	**Date:** 26 June 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.

Organisation	Method	Feedback	Woodside assessment	Woodside's response
International Fund for Animal Welfare	Email with fact sheet	**Date:** 26 June 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.