North Rankin Complex Operations Environment Plan Summary

Production Environment

May 2017

Revision 1

TABLE OF CONTENTS

1. INTRODUCTION

In accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations* 2009 (Cth) (Environment Regulations), Woodside Energy Ltd (Woodside), as the nominated titleholder on behalf of the North West Shelf (NWS) Project participants (Woodside, BHP Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Pty Ltd, CNOOC NWS Private Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd and Shell Development (Australia) Pty Ltd, operates the North Rankin Complex (NRC), which has been in production since 1984. NRC is a single integrated facility comprised of two platforms, the North Rankin A (NRA) platform and the North Rankin B (NRB) platform.

This Environment Plan (EP) Summary has been prepared to meet the requirements of Regulations 11(3) and 11(4) of the Environment Regulations, as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). This document summarises the North Rankin Complex Facility Operations Environment Plan (the NRC Operations EP), accepted by NOPSEMA under Regulation 10A of the Environment Regulations.

1.1 Defining the Activity

The Petroleum Activities Program to be undertaken in production licence area WA-1-L consists of:

- routine production
- routine Inspection, Maintenance and Repair (IMR) of the platforms and associated subsea infrastructure, including pigging of the flowlines and trunklines
- well intervention, workovers and well kill activities of platform based wells
- non-routine and accidental activities and incidents associated with the above.

The infrastructure covered by this EP includes the:

- the NRC comprising the NRA and NRB platforms
- wells and subsea infrastructure associated with or tied back to the NRC
- the NRC trunklines located in Commonwealth waters (operated under WA-1-PL & WA-10-PL)
- support vessels assisting with activities defined above.

2. LOCATION OF THE ACTIVITY

The NRC and associated infrastructure is located in Commonwealth waters on the NWS in production license area WA-1-L, approximately 135 km north-west of Dampier and 23 km north east of the Goodwyn Alpha (GWA) platform (**Figure 2-1**). The facility stands in approximately 125 m of water.

Gas and condensate produced from the facility are exported onshore via two 130 km trunklines for processing. Product can be routed via the 40” first (1TL) trunkline or 42” second trunkline (2TL). Approximately 105 km of the trunkline length is located in Commonwealth waters and included in the scope of the NRC Operations EP; the remaining lengths are located in State waters and are the subject of a separate EP.

As part of the Persephone development, a new flowline, the Persephone tie back flowline, runs to the Persephone gas field, approximately 6.9 km north-east of NRC. This flowline will transport well fluids back to NRC for processing.

The NRC is marked on nautical charts, and is surrounded by a 500 m exclusion zone. The platforms are categorised as a Danger Area for civil aircraft, and marked on aeronautical charts.

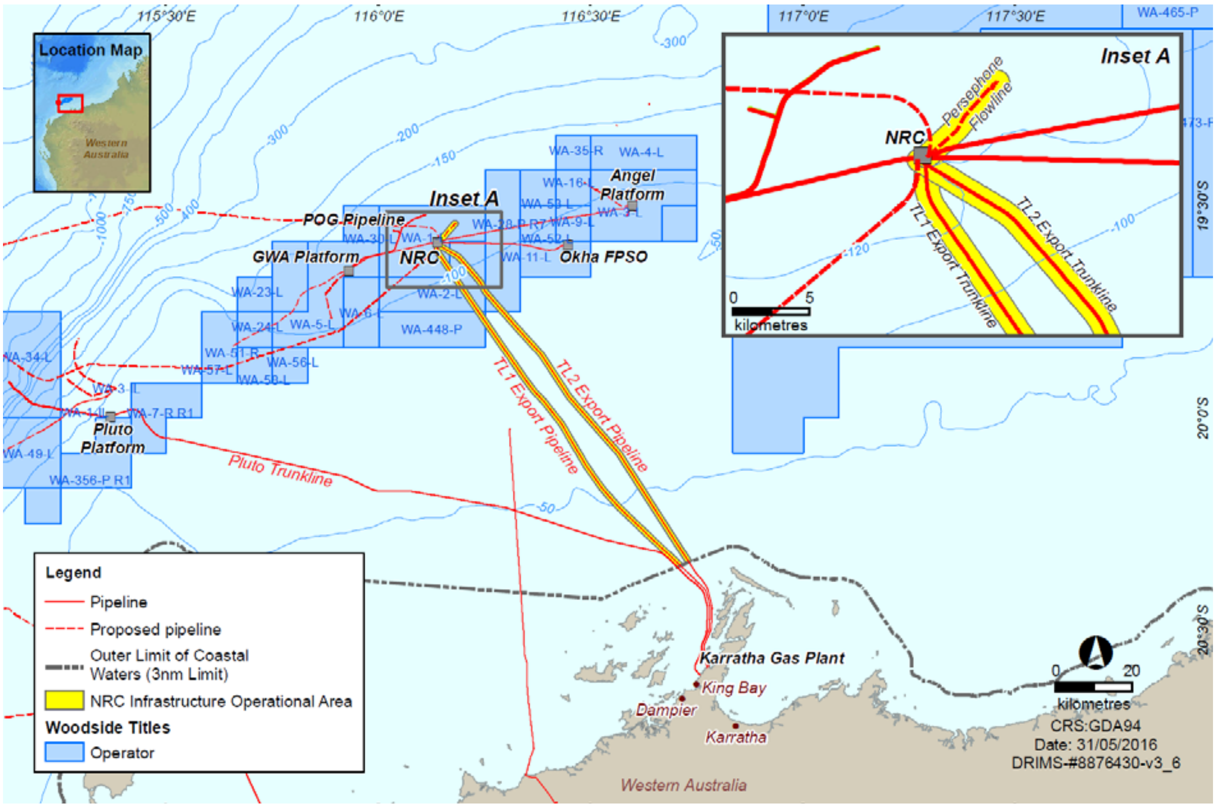

Figure 2-1: Location of the Petroleum Activities Program

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

- NRC and the area within a 500 m exclusion zone around the facilities
- NRC subsea infrastructure and the area within 1500 m around the infrastructure
- the first and second trunklines (1TL and 2TL) between the NRC and the State waters boundary (3 nm from the shore) and the area within 1500 m around the trunklines.

The Operational Area (**Figure 2-1**) does not overlap with any established or proposed Marine Protected Areas (MPAs). Approximate coordinates for the NRC and associated infrastructure are provided in **Table 2-1**. The closest nearshore sensitive receptors to the NRC is the State boundary of the Barrow Island (125 km south-west), the Montebello and Lowendal Island groups (95 km south-west), the inshore habitats and shoreline of the Dampier Archipelago (125 km south-east) and the mainland (135 km south-east).

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

Structure	Latitude	Longitude	Production / Pipeline Licence
NRA Platform	19° 35’ 03.23”S	116° 08’ 17.06”E	WA-1-L
NRB Platform	19° 35’ 02.52”S	116° 08’ 11.32”E	WA-1-L
PSA 01 Well	19° 32’ 24.256” S	116° 10’ 50.012” E	WA-1-L
PSA 02 Well	19° 32’ 22.260” S	116° 10’ 51.096” E	WA-1-L
PSP Flowline	-	-	N/A[1]
1TL - First Trunkline tie-in point to NRA	19° 35’ 03.12”S	116° 08’ 19.88”E	WA-1-PL
2TL - Second Trunkline tie-in point on the GWA Interfield Line	19° 35’ 07.94”S	116° 08’ 05.06”E	WA-10-PL
1TL – First Trunkline at outer limit of Western Australian State waters boundary (3 nm)	20° 20’ 49.49”S	116° 42’ 40.80”E	TPL/15
2TL – Second Trunkline at outer limit of Western Australian State waters boundary (3 nm)	20° 20’ 20.26”S	116° 43’ 54.17”E	TPL/16
East end of Angel export pipeline[2] (Angel facility)	19° 29' 52.80"S	116° 35' 49.40"E	WA-14-PL
West end of Angel export pipeline[2] (NRC)	19° 35' 09.27"S	116° 08' 24.14"E	WA-14-PL
West end of GWA Inter-field Pipeline[3] (GWA facility)	19° 39' 07.68"S	115° 55' 50.88"E	WA-2-PL
East end of GWA Inter-field Pipeline[3] (NRA facility)	19° 35' 04.62"S	116° 08' 16.50"E	WA-2-PL
East end of Okha Export Pipeline[4] (Okha facility)	19° 35' 20.92"S	116° 26' 33.75"E	WA-4-PL
West end of Okha Export Pipeline[4] (NRA facility)	19° 35' 07.14"S	116° 08' 21.88"E	WA-4-PL

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[1] *No pipeline licence required for Persephone (PSP) flowline as line has been classified as a secondary pipeline.*

[2] *Covered by the Angel Facility Operations EP*

[3] *Covered by the Goodwyn Facility Operations EP*

[4] *Covered by the Okha Facility Operations EP*

3. DESCRIPTION OF THE ACTIVITY

3.1 Purpose of the Activity

The purpose of the activity is the operation of the NRC, during both routine and non-routine operations.

3.2 Timing of the Activities

The NRC operates 24 hours a day, 365 days a year. Supporting operations, such as maintenance activities, take place as required.

The end of life of the North Rankin and Perseus fields is not predicted during the life of this EP.

3.3 Facility Layout and Description

The NRC is central to Woodside's NWS Facilities and has interactions with the following facilities:

- GWA platform via a 23 km, 30" inter-field pipeline (IFL)
- Karratha Gas Plant (KGP) via two 130 km, 40" (1TL) and 42" (2TL) export trunklines
- Angel platform via a 50 km, 30" pipeline and power umbilical. NRC also has full remote control of Angel when it is not manned
- Okha FPSO via a 33 km, 12" export pipeline.

The 40" 1TL and 30" IFL are connected to the NRC topside through risers. All other pipelines are connected to either 1TL or 2TL via various different subsea tie-in assemblies.

3.3.1 Topsides

The NRA platform is comprised of an eight-legged steel piled jacket with a piled and guyed steel tripod flare support structure. There are six main levels on NRA, with the production deck at an elevation of 23 m above sea level. The accommodation modules (Modules 11/12) are at the southern end of the platform and are segregated from the hydrocarbon processing equipment and flare systems by the utilities and drilling support modules. The product export pipeline riser is located near the centre of the platform.

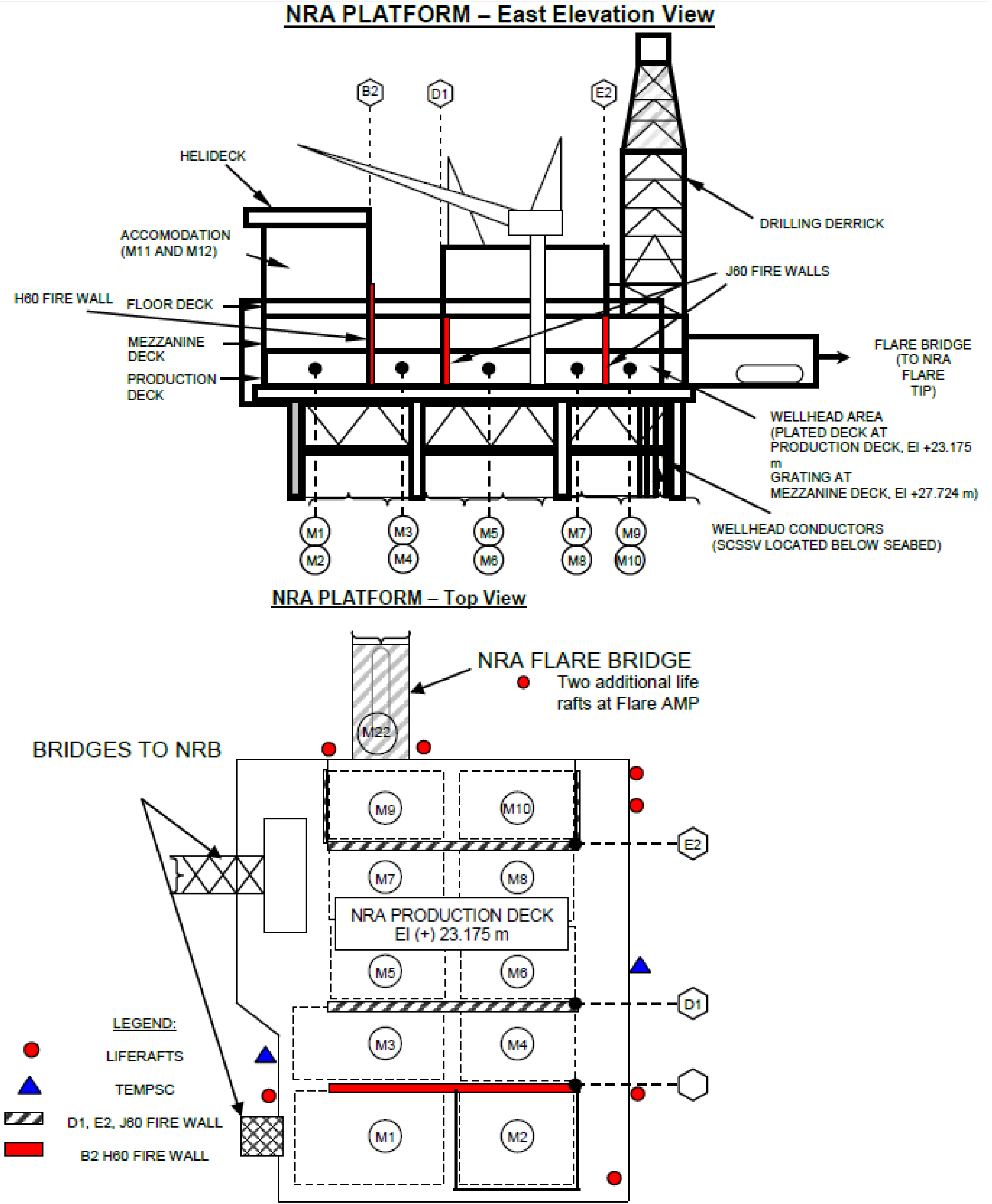
The NRA platform consists of 23 topsides modules, as shown in **Figure 3-1**.

The NRB platform is situated approximately 100 m west of the NRA jacket. The NRB platform comprises a four-legged piled steel jacket with an integrated float over deck at an elevation of 28 m above sea level. The main function of the NRB platform is to provide gas compression and condensate pumping for the well fluids produced from the NRA wells.

The NRB platform consists of the topside areas shown in **Figure 3-2**.

The NRA and NRB platforms are connected by two bridges. The north (pipe) bridge supports all the interconnections as well as provisions for maintenance and material traffic. The interconnections include flowlines, utility lines, instrument lines and electric cabling. The south bridge is for pedestrian use only.

The diesel powered, hydraulic driven pedestal mounted platform cranes perform lifting operations associated with supply vessels and operations, maintenance and project work scopes.



NRA PLATFORM – East Elevation View

NRA PLATFORM – Top View

Area	Description
A-Module 1/2	Generation/Power Distribution
A-Module 3/4	Utility/Electrical
A-Module 5/6/7/8	Process Area
A-Module 9/10	Wellheads
A-Module 22	Flare Bridge

Figure 3-1: NRA facility layout

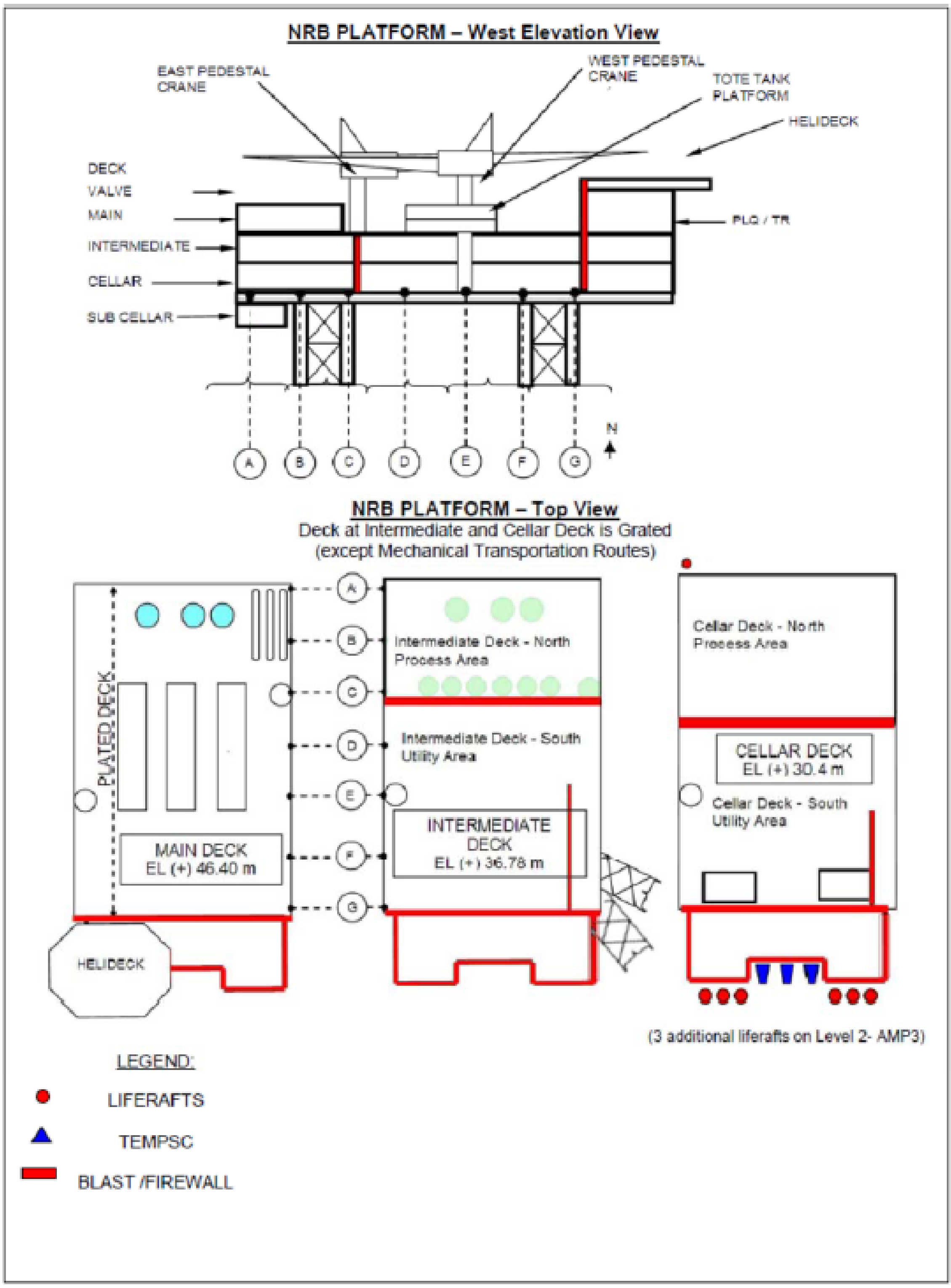


Figure 3-2: NRB facility layout

3.3.2 Reservoirs

The NRC produces fluids from the following reservoirs:

- North Rankin
- Perseus over North Rankin
- Persephone.

3.3.3 Well Configuration

There are a total of 29 platform based wells currently in production on NRC. Seven of these production wells are in the Perseus over North Rankin reservoir with the remaining 22 wells in the North Rankin reservoir. All these wells are platform based wells with the wellheads located on the NRA platform.

Tubing retrievable sub surface safety valves (SSSV) and wireline retrievable SSSVs are installed on NRC wells as the primary down-hole safety system. A hydraulically operated flow wing valve and a manual kill wing valve are attached to the wellhead. The production choke is pneumatically operated, located on the wellhead and controls the well flow.

Control of the wellhead and the SSSV is via a hydraulic control line from the SSSV to the wellhead control panel. The SSSVs close on loss of hydraulic pressure.

Two production wells within the Persephone reservoir tie back to the NRC via a 6.9 km 12” flowline. Control and monitoring of the subsea wells is through an electrohydraulic umbilical from NRC.

Control of the wellhead and the Surface Controlled Subsea Safety Valve (SCSSV) are via an electro-hydraulic umbilical from NRC to the Persephone trees. The SCSSVs fail safe closed on loss of hydraulic pressure.

3.3.4 Pipeline and Riser System

NRC receives production fluids (gas, condensate and associated produced water) from the wells on NRA, with the fluid then routed across the bridge for processing and compression on NRB prior to being routed back to NRA for gas dehydration and condensate dewatering. The export manifolds on NRA then send the processed gas and condensate to the KGP via two trunklines.

3.3.5 Subsea Infrastructure

The scope of this EP includes all subsea infrastructure associated with production from the NRC to the state waters boundary. The NRC subsea infrastructure includes the tie-spools from the GWA, Angel and export lines and the components listed below:

- two 130 km export trunklines (40” (ITL) and 42” (2TL))
- spools
- electric and hydraulic jumpers
- umbilicals
- risers
- flowline
- manifold
- wellhead /tree (including choke module and SCM)

- jacket legs
- integrated valve skid
- pig receivers
- gravity anchors
- conductors
- subsea isolation valve
- tie-in structures and skids
- gravity box anchor
- Angel power cable
- Persephone Flowline End Termination
- well jumpers.

The NRC Central Control Room (CCR) is responsible for controlling the following subsea components:

- valves which control subsea operations and processes
- chokes which control pressure and flow rates of hydrocarbons.

The above components regulate the flow of hydrocarbons through the subsea spools, flowline and trunklines. Jumpers and umbilicals provide hydraulic and electric power, communications and chemical supplies to the subsea infrastructure.

The offshore facilities also have local control capability to facilitate operations during emergency incidents and maintenance activities, and a standby communications link is available in the event of failure of the primary link.

A number of subsea valves may also be overridden manually from a Remote Operated Vehicle (ROV). The control system design ensures the subsea trees cannot be operated from the facility or the onshore CCR whilst a well intervention is underway on that well, and certain intervention-only functions cannot be operated from the facility.

3.4 Operational Details

3.4.1 Manning and Operations

Total overnight persons onboard (PoB) capacity for the NRC is 330 persons. The CCR is manned 24 hours per day. Activities which affect manning levels are:

- crew change
- engineering projects
- campaign maintenance
- inspections/audits
- planned facility shutdowns.

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

- production and maintenance
- production and well maintenance
- subsea IMR activities

- production and major projects
- remote operations.

3.4.2 Process Description

The NRC has three processing trains (Trains 100, 200, 300) designed for gas export plus associated condensate.

The NRC operates a flare system that is used during normal (routine and non-routine) operations and emergency flaring (if required).

3.4.2.1 Produced Water Management

Produced water (PW) brought to the surface during production is separated from hydrocarbons and discharged to the marine environment in accordance with legislative requirements. PW comprises both produced formation water and condensed water.

In normal operations, produced water is discharged overboard following treatment in the produced water centrifuge. The inclusion of an additional centrifuge for the Persephone project will provide some safeguard for PW processing redundancy, however if there is no centrifuge online, produced water bypasses the centrifuge(s) and is directed (manually controlled) from the degasser to the drain sump caisson. In this instance, production rates may be reduced and other operational measures implemented to manage Oil in Water (OIW) concentrations within the 30mg/l (average over 24hour period) Performance Standard requirements. Once directed to the caisson produced water will not immediately be discharged to the environment, and an additional level of oil/water gravity separation will occur within the caisson. The condensate-gas and condensate-water interfaces in the Drain Sump Caisson are monitored by two independent level indicators. The Drain Sump Caisson Pump maintains the water-condensate level within an operating band by pumping the condensate layer to the Recovered Oil Tank which can subsequently be pumped to the export pipeline. Water within the Drain Sump Caisson is discharged to the environment at 40 m below sea level.

3.4.3 Drainage System

The open 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. The NRA and NRB open drains are similar in design, but independent systems.

3.4.4 Utility Systems

The NRC complex has in place a range of utility systems to support operations, including:

- platform lighting
- heating, ventilation and air conditioning system
- water systems, including:
  - seawater/service water system
  - tempered water system
  - chilled water
  - potable water

- power generation
- accommodation facilities
- sewage and putrescible waste systems
- produced sand management system.

3.4.5 Facility Operations

A range of operations may take place at the NRC, including:

- lifting operations
- diesel bunkering and usage
- support vessel operations
- helicopter operations
- maintenance of auxiliary systems during de-manning.

3.4.6 Hydrocarbon and Chemical Inventories and Selection

A range of hydrocarbons may be present at the NRC, including:

- hydrocarbons within the NRA and NRB process inventories
- inventories of non-process hydrocarbons, such as fuel (diesel), lubricating oil and heating oil.

A range of chemicals may be present onboard the NRC which may be used as operational process chemicals, operational non-process chemicals and facility maintenance chemicals. Chemicals used at the NRC may include:

- corrosion inhibitor
- demulsifier
- water clarifier
- aqueous film forming foam concentrate
- glycol (e.g. triethylene glycol, monoethylene glycol)
- subsea fluid
- coolant
- oxygen scavenger
- pH buffer
- biocide.

All chemicals are required to undergo a chemical selection, assessment and approval process. This process is used to demonstrate that the potential impacts of the chemicals selected are acceptable and As Low As Reasonably Practicable (ALARP) (subject to technical and economic constraints).

3.4.7 Subsea Inspection, Maintenance and Repair Activities

A range of subsea inspection, monitoring, maintenance and repair activities (referred to as IMR) may be undertaken during the operational of the NRC. 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 a dynamic positioning (DP) system to allow manoeuvrability and avoid anchoring when undertaking works due to the close proximity of subsea infrastructure. IMR activities may include:

- subsea vessels and equipment
- inspections
- chemical usage
- intervention isolation
- pressure and leak testing
- flushing
- marine growth removal
- sediment relocation
- hotstab interventions
- corrosion protection
- blasting and painting
- stabilisation / span rectification
- cycling of valves
- umbilical and jumper replacement
- pipeline / flowline repair and spool replacement
- riser removal and replacement
- choke change out
- subsea control module change out.

3.4.8 Platform Well Management and Maintenance Activities

Well management and maintenance for platform-based well may be undertaken from the NRC, and may include:

- well intervention: may be undertaken for reservoir surveillance, enhancing productivity / injectivity, assessing wellbore condition and restoring well integrity. Routine well maintenance is conducted regularly on all surface wellheads/trees
- well workover: well workovers generally involve he recovery and reinstallation or replacement of production / injection completion strings
- well kill: displacement of 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 undertaken if well integrity is compromised, or to support intervention or workover activities.

Interventions or the NRC subsea wells require a suitable vessel or drill rig to accommodate and support intervention packages and do not form part of the scope of this EP summary.

3.4.9 Remote Operations

The NRC remains manned during a cyclone under normal circumstances. However, there may be exceptional circumstances such as severe cyclones (Category 4 or 5) that may require the pre-planned partial down manning or evacuation of all personnel from the facility (de-manning). Woodside implements a staged approach to the de-manning the NRC which considers:

- forecast location, category, speed and variability of the cyclones calculated path
- total PoB on the facility at the time of cyclone development
- aviation / logistics availability and capacity to down man
- standby vessel availability.

As a precautionary safety measure, it is Woodside's intention to temporarily de-man the NRC in the event of a severe cyclone, whilst maintaining operation of the facility via a Remote Operation Station at the KGP.

The duration for which NRC will be operated un-manned is subject to intensity and duration of possible cyclones and the logistics associated with re-manning the platform. Notwithstanding the above, it is estimated that remote operation will occur for a period of between three to seven days.

Whilst remotely operated, the NRC 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.

3.4.10 Selection, Assessment and Approval of Chemicals

Chemical selection for the replacement of current chemicals (e.g. in the event of product substitution, or a superior product being released), or introduction of new chemicals (e.g. for new process/production requirements) complies with Woodside's corporate requirements as outlined in Woodside's Environmental Performance Operating Standard, which requires chemicals to be selected with the lowest practicable environmental risk.

Woodside's Environmental Chemical and Assessment procedure assesses chemicals based on toxicity, biodegradation and bioaccumulation to select an appropriate product. Selection will be based on the United Kingdom's Offshore Chemical Notification Scheme (OCNS).

- Chemicals that are Gold, Silver, group E and D under the OCNS Definitive Ranked Lists and have no substitution warning do not require further assessment, as they do not represent a significant impact on the environment in standard discharge scenarios.
- Chemicals not meeting the criteria above (i.e. OCNS white, blue, orange, purple, A, B, C or have product/substitution warning) require additional assessment to understand the environmental implications for an expected portion to be discharged into the marine environment.
- Chemicals that are not OCNS registered require further assessment to determine the environmental implications if the chemical is discharged into the marine environment.

The selection of chemicals that fall into the last two assessment types require the additional development of an ALARP justification using a standard template and are subject to periodic review as part of the continuous improvement of chemical selection and usage.

4. DESCRIPTION OF THE RECEIVING ENVIRONMENT

In determining the spatial extent of the environmental sensitivities that may be affected, Woodside considered both the Operational Area (for planned and unplanned activities), as well as the credible Zone of Consequence (ZoC) (refer to **Section 5.2** for additional information on the ZoC) of the credible worst case hydrocarbon spill scenarios.

4.1 Regional Setting

The NRC is located within the Commonwealth waters of the NWS, approximately 135 km north west of Dampier, in water depths of approximately 125 m. The NWS is part of the wider North West Marine Region (NWMR) as defined under the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0). 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. The NWS province is characterised by the following bio-physical features:

- transitional climatic conditions between dry tropics to the south and humid tropics to the north
- strong seasonal winds and moderate off-shore tropical cyclone activity
- deeper surface waters are tropical year-round and highly stratified during summer months (thermocline occurring at water depths between ~30 to 60 m). In winter surface waters are well mixed with thermoclines (at ~120 m depth)
- surface ocean circulation is strongly influenced by the Indonesian Throughflow (ITF) via the Eastern Gyre. During the summer when the ITF is weaker, south west winds cause intermittent reversals in currents. These events may be associated with occasional weak, shelf upwellings
- the seabed in the region consists of sediments that generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the slope and abyssal plain. Approximately 60-90 % of the sediments in the region are carbonate derived
- the region has high species richness, but a relatively low level of endemism, i.e. species particular to the region in comparison to other areas of Australian waters
- benthic communities range from nearshore benthic primary producer habitats such as seagrass beds, coral communities and mangrove forests to offshore soft sediment seabed habitats associated with low density sessile and mobile benthos such as sponges, molluscs and echinoids
- presence of internationally significant migratory routes, resident populations, breeding and/or feeding grounds for a number of EPBC Act listed threatened and migratory marine species, including humpback whales, marine turtles, whale sharks, seabirds and migratory shorebirds
- Key Ecological Features (KEFs) in the region include the high diversity Continental Slope Demersal Fish Communities and Ancient coastline at 125 m depth contour, which may promote mixing and productivity. Rankin Bank and Glomar Shoals which are offshore submerged shoals are also notable features in the region.

4.2 Physical Environment

The climate within the region is dry tropical, exhibiting a hot summer season from October to April and a milder winter season between May and September. Rainfall in the region typically occurs during the wet season (summer), with highest rains observed during late summer often associated with the passage of tropical low pressure systems and cyclones. Rainfall outside this period is typically low. There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds.

The large-scale ocean circulation of the NWS is primarily influenced by the ITF and the Leeuwin Current. Both of these currents are significant drivers of the region's ecosystems. The currents are driven by pressure differences between the equator, and the higher density, cooler and more saline waters of the Southern Ocean. The ITF and Leeuwin Current are strongest during late summer and winter.

In addition to the synoptic-scale current dynamics, tidally driven currents are a significant component of water movement on the NWS. Tides in the NWS region are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south east and ebbing towards the north west. Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights.

Broad-scale surveys confirm that the seabed is flat and relatively featureless and no areas of hard outcropping are known within 2 to 3 km of the NRC. The seabed in the vicinity of the NRC is typical of deeper offshore areas (>150 m water depth) on the NWS, being characterised by deep (>5 m) soft, silty sediments derived primarily from calcium carbonate, which become deeper, softer and finer with increasing depth.

4.3 Biological Environment

No Critical Habitats or Threatened Ecological Communities, as listed under the EPBC Act, occur within the Operational Area.

4.3.1 Benthic Communities

Studies have revealed that the infauna associated with soft unconsolidated sediment habitat in the NWS area is widespread and well represented along the continental shelf and upper slopes. Benthic grab sampling around the NRC platform revealed a low abundance but high variability and diversity of infauna, dominated by polychaetes and crustaceans.

Sea floor communities in deeper (>100 m) shelf waters receive insufficient light to sustain ecologically sensitive primary producers such as seagrasses, macroalgae or zooxanthellate scleractinian (reef building) corals. Given the depth of water in which the NRC is situated (125 m), these benthic primary producer groups will not occur in the Operational Area. Infrastructure in the upper water column and euphotic zone may support the establishment of sessile benthos such as macroalgae and coral.

Sedimentary infauna associated with soft unconsolidated sediments at the Operational Area is widespread and well represented along the continental shelf and upper slopes in the NWS region.

4.3.2 Plankton

Primary productivity of the NWS is largely driven by offshore influences, with periodic upwelling events and cyclonic influences driving coastal productivity, and with nutrient recycling and advection. Cyanobacteria and diatoms are the predominant phytoplankton contributors. It is expected that the dominant primary consumers are copepods, with a wide range of secondary consumers, comprising larger planktonic taxa (including larval fish and invertebrates.

The oligotrophic offshore waters of the region (which include that of the NRC Operational Area) support low phytoplankton biomass and low primary productivity. Phytoplankton of the region exhibit recorded concentrations below the thermocline or at the bottom mixed-layer, with evidence of a deep chlorophyll maximum at around 100 m. There is a tendency for offshore phytoplankton communities in the region to be characterised by smaller taxa (e.g. bacteria), while shelf waters are dominated by larger taxa such as diatoms.

Satellite datasets from the NWMR showed that chlorophyll (and inferred phytoplankton) levels are low in summer months (December to March) and higher in winter months (June to August). Further observations associated with the low chlorophyll levels in summer include light limitations on plankton growth due to high cloud cover, nutrient limitations from an overlying surface layer that is low in nutrients, productivity at depth (unavailable for satellite detection, or some combination of these factors.

The inshore ichthyoplankton assemblage is characterised by shallow reef fishes such as blennies (family Blenniidae), damselfish (family Pomacentridae) and north west snappers (family Lethrinidae), while offshore assemblages are dominated by deepwater and pelagic taxa such as tuna (family Scombridae) and lanternfish (family Myctophidae). Some of these taxa are commercially and recreationally important species in the region.

Zooplankton abundance in the region is linked to phytoplankton productivity, with seasonal peaks in late summer. An important component of the zooplankton offshore from the North West Cape is krill, which is an important food for Whale Sharks aggregating in the region. Large swarms of krill have been detected in the shallow coastal waters offshore from Ningaloo Reef from March to July, and this has been linked to localised upwelling of nutrient rich water supporting increased phytoplankton productivity.

4.3.3 Species

The search for the Operational Area and wider entrained hydrocarbon ZoC for the worst case credible scenario identified a total of 89 EPBC Act listed marine species that may occur within the area, 35 were identified as potentially occurring within the Operational Area. Of these 13 are considered threatened marine species and 24 migratory species under the EPBC Act.

Seabirds

The NRC Operational Area and wider ZoC may be occasionally visited by migratory and oceanic birds. These included a number of species of petrel, shearwater, tropicbird, frigatebird, booby and tern, as well as the silver gull. No roosting or nesting habitat exists within the NRC Operational Area, and there are no Ramsar Convention protected sites in the surrounding area. The nearest Ramsar sites, Eighty Mile Beach and Roebuck Bay, are located over 669 km to the north east.

There are a number of notable mainland coastal and island locations that are important seabird (e.g. terns, shearwaters and tropicbirds) and shorebird (e.g. sandpipers and greenshanks) feeding, breeding and nesting sites. A number of island groups such as the Montebello's and closer to the mainland, such as the islands of the Dampier Archipelago, and the Great Sandy and Passage Island Groups (Pilbara Inshore Region), are important seabird and shorebird nesting and foraging habitats. The NRC is located over 107 km from the closest of these locations.

Migratory shorebirds travelling the East Asian-Australasian Flyway may transit through the Operational Area en route to these staging areas before moving onto the mainland south in the spring and 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 Operational Area to rest. Migratory shorebirds may be present in the region between July and December and again between March and April as they complete migrations between Australia and offshore locations.

Within the wider ZoC beyond the Operational Area, a range of other migratory seabirds and shorebirds may be encountered. Based on the results of two survey cruises and other unpublished records, Dunlop et al, (1995) recorded the occurrence of 18 species of seabirds over NWS waters. These included a number of species of Petrel, Shearwater, Tropicbird, Frigatebird, Booby and Tern, as well as the Silver Gull. Of these, eight species occur year round and the remaining ten are seasonal visitors. From these surveys, it was noted that seabird distributions in tropical waters were generally patchy except near islands.

Marine Mammals

Humpbacks whales (*Megaptera novaeangliae*) are most likely to occur in the Operational Area and wider ZoC between July and September during the migration period and are most likely to be transiting through the area, rather than resting, breeding or feeding. Pygmy blue whales (*Balaenoptera musculus brevicauda*) may occur in the Operational Area and wider ZoC; however, individuals generally transit the deeper offshore waters to the west of the Operational Area during their northern and southern migrations. Other cetacean species may infrequently transit the Operational Area; however, the Operational Area does not represent any critical habitat (feeding, resting or breeding aggregation areas) for cetacean species that may occur in the region.

Dugongs (*Dugong dugon*) are large herbivorous marine mammals that feed on seagrass beds and macroalgae in coastal areas. The closest dugong habitat to the NRC Operational Area is located to the south at the Montebello Islands and Lowendal Island. Given the offshore location and deep water depths, the NRC Operational Area does not support primary producer habitat for grazing and is not a critical habitat for Dugongs. Dugongs may transit the NRC Operational Area, but is considered unlikely given the offshore location.

Marine Mammals in the Wider ZoC

Several marine mammals were identified as potentially occurring beyond the Operational Area, but within the wider ZoC, including:

- The southern right whale, which is listed as endangered under the EPBC Act. The southern right whale occurs primarily in waters between approximately 20° and 60°S and moves from high latitude feeding grounds in summer to warmer, low latitude, coastal locations in winter (Bannister et al. 1999). Sightings in more northern waters are relatively rare; however, they have been recorded as far north as Exmouth (Bannister et al. 1996). Given the species prefers temperate waters and has rarely been recorded north of Exmouth, southern right wales are very unlikely to occur in the wider ZoC. Its also noted that no BIAs overlap the wider ZoC.
- The dusky dolphin, which is a coastal dolphin species with a broad (although patchy) distribution in temperate waters throughout the southern hemisphere. Populations occur in waters off South America, South Africa, southern Australia and New Zealand (DoEE 2016). The dusky dolphin has a preference for cooler (<18 °C) waters (Bannister et al. 1996), which may limit their distribution along the Western Australian coastline, where the southward-flowing warm water Leeuwin Current is present. The dusky dolphin is not expected to occur in the Operational Area, although it may occur in the southernmost extent of the ZoC.
- The Australian sea lion is the only endemic pinniped in Australia, with only 76 known breeding colonies ranging from the Abrolhos Islands off Western Australia to the Page Islands, South Australia (DSEWPaC 2012a). Australian sea lions prefer the sheltered side of islands, with shallow, protected pools in which pups congregate. On the west coast of Western Australia, rookeries are found on low-lying limestone islands that are well protected by perimeter reefs. The nearest known significant colony within the wider ZoC is situated at the Abrolhos Islands, which hosts a foraging

BIAs for male and female Australian sea lions. This BIA lies at the southern extremity of the ZoC.

Marine Reptiles

Five of the six marine turtle species recorded for the NWS province were identified as possibly occurring within the Operational Area and wider ZoC. The marine turtles identified were: the green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), and the flatback turtle (*Natator depressus*). Four of the turtle species (green, loggerhead, flatback and hawksbill) have significant nesting beaches along the mainland coast and islands in the region including the Montebello Islands, Barrow Island, Dampier Archipelago, Muiron Islands, the North West Cape and Ningaloo Reef.

With consideration of the distance offshore (approximately 106 km north of the Montebello Islands), depth range of surrounding offshore waters (approximately 85 m to 1000 m), and absence of potential nesting or foraging sites (i.e. no emergent islands, reef habitat or shallow shoals) the Operational Area is not considered an important habitat for marine turtles. Furthermore, while it is acknowledged that there are significant nesting sites along the mainland coast and islands of the region, the primary nesting locations (such as Montebello Islands) are at least 56 km from the Operational Area.

Sea snakes occur in the NWS province in waters up to approximately 100 m depth and are reported to occur in offshore and nearshore waters of the Pilbara region. Sea snakes of the families Hydrophidae and Laticaudidae are widespread in the region, and are protected under the EPBC Act. The protected matters search highlighted 16 species of sea snake listed under the EPBC Act that may occur in the Operational Area and wider ZoC. The short-nosed sea snake (*Aipysurus apraefrontalis*) is a species endemic to Western Australia and is listed as Critically Endangered. This species of sea snake inhabits shallow reefs and has been recorded from Exmouth Gulf to the reefs of the Sahul Shelf. The most commonly sighted sea snake in the region is the olive seasnake (*Aipysurus laevis*). Large, deep water expanses create a significant barrier to seasnake movement. It is considered that seasnake presence will be infrequent and likely comprise few individuals within the Operational Area and wider ZoC.

Sharks, Rays and Fishes

Whale sharks (*Rhincodon typus*) aggregate annually to feed in the waters around Ningaloo Reef from March to July, with the largest numbers recorded in April and May. However seasonal aggregation can be variable, with individual whale sharks recorded at other times of the year. Timing of the whale shark migration to and from Ningaloo coincides with the coral mass spawning period when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef. Whale sharks may traverse the Operational Area and wider ZoC during their migrations to and from Ningaloo Reef. However, it is expected that whale shark presence within the Operational Area and wider ZoC would be of a relatively short duration and not of significant numbers given the main aggregations are recorded in coastal waters, particularly, the Ningaloo Reef edge.

Several other shark/ray species, including the great white shark (*Carcharodon carcharias*), grey nurse shark (*Carcharius taurus*), green sawfish (*Pristis zijsron*), shortfin mako (*Isurus oxyrinchus*), longfin mako (*Isurus paucus*) and giant manta ray (*Manta birostris*) may be present within the Operational Area and wider ZoC, for short durations when individuals transit the area.

A total of 57 teleost fish species from the family Syngnathidae, which are listed under the EPBC Act were identified as potentially occurring within the NRC Operational Area and wider ZoC by the protected matters search tool. Syngnathids are commonly found in seagrass and sandy habitats around coastal islands and shallow reef areas along the NWS. However bycatch data indicates they are uncommon in deeper continental shelf waters (50 m to 200 m) and therefore unlikely to occur within the NRC Operational Area.

Additional features relating to the fish populations of the area are as follows:

- The fish fauna in the Pilbara region is considered to be diverse and show a trend of decreasing species richness with increasing depth. Fish species richness has been shown to correlate with habitat complexity, with more complex habitat supporting greater species richness and abundance than bare areas.
- The NRC Operational Area comprises featureless, flat soft sediment seabed, and consequently the natural fish fauna are not expected to be abundant and diversity is expected to be limited due to the lack of hard substrate/ habitat complexity. It is noted however that fish abundance and diversity increases with presence of artificial infrastructure. For example, a study of fish diversity present around offshore NWS oil and gas facilities indicated up to 13 species of large fish (including Epinephelus – Cod, Lutjanus – Snapper and Carangoides – Trevally) are present around offshore NWS oil and gas facilities.
- The NRC protected matters search report identified the Continental Slope Demersal Fish Communities as a Key Ecological Feature in the region. Diversity of demersal fish assemblages on the continental slope between North West Cape and the Montebello Trough is the highest in Australia (>500 species of which 76 are endemic). Demersal fish species occupy two distinct demersal community types (biomes) associated with the upper continental slope (water depth of 225 to 500 m) and the mid continental slope (750 to 1000 m) relying on bacteria and detritus-based systems comprised of infauna and epifauna, which in turn become prey for a range of teleost fish, molluscs and crustaceans. Higher-order consumers may include carnivorous fish, deepwater sharks, large squid and toothed whales.
- Further to the South of the NRC Operational Area:
    - The North West Cape marine region is a transition area for demersal shelf and slope fish communities between the tropical dominated communities to the North and temperate communities to the South. The benthic shelf and slope communities offshore of the North West Cape comprise both tropical and temperate fish species with a North South gradient.
    - The fish fauna of the North West Cape area, like the ichthyofauna of many regions, exhibits decreasing species richness with depth. Fish species diversity has been shown to be positively correlated with habitat complexity, with more complex habitats (e.g. coral reefs) typically hosting higher species richness than simpler habitats such as bare, unconsolidated muddy sediments. A total of 500 finfish species from 234 genera and 86 families have been recorded within the Ningaloo Marine Park and 393 species at study sites of the Muiron Islands.

4.4 Socio-economic Environment

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

Several heritage properties protected under the EPBC Act occur within the wider ZoC, including:

- World Heritage Places:
    - The Ningaloo Coast
    - Shark Bay

- National Heritage Places:
  - The Ningaloo Coast (natural heritage place)
  - Shark Bay (natural heritage place)
  - Dampier Archipelago (including Burrup Peninsula) (Indigenous heritage place)
  - Dirk Hartog Landing Site 1616 - Cape Inscription Area (historic place)

No tourism activities take place specifically within the Operational Area, however, it is acknowledged that there are growing tourism and recreational sectors in Western Australia (including the wider ZoC) and these sectors have expanded in area over the last couple of decades. The main marine nature-based tourist activities in the region are concentrated around and within the Ningaloo Marine Park and North West Cape area. The Montebello Islands are the closest location for tourism to the Operational Area with some charter boat operators taking visitors to these remote islands. Due to water depths and distance offshore, recreational fishing is unlikely to occur in the Operational Area and recreational fishing vessels will be subject to a 500 m exclusion zone around the NRC.

The Operational Area is located within an area of established oil and gas operations. Other facilities (all of which are operated by Woodside) located in proximity to the Operational Area and within the wider ZoC include:

- Goodwyn – approximately 23 km south west of NRC
- Okha – approximately 32 km east of NRC
- Angel – approximately 49 km north east of NRC
- Pluto– approximately 95 km south west of NRC.

Commonwealth fisheries overlapping or adjacent to the Operational Area include

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

State fisheries overlapping or adjacent to the Operational Area include:

- West Australian Mackerel Fishery
- Pilbara Fish Trawl and Trap Fishery (part of the North Coast Demersal Scalefish Fishery)
- Onslow Prawn Managed Fishery (North Coast Prawn Managed Fisheries)
- Exmouth Gulf Prawn Fishery
- Nickol Bay Prawn Managed Fishery
- Pearl Oyster Managed Fishery
- Pilbara Developing Crab Fishery.

The majority of fishing effort in relation to these fisheries occurs beyond the Operational Area. There are no aquaculture activities within the Operational Area. Aquaculture in the region consists primarily of culturing hatchery reared and wild caught oysters (*Pinctada maxima*) for pearl production. Leases typically occur in shallow coastal waters at depths of less than 20 m

The region supports significant commercial shipping activity, the majority of which is associated with the mining, oil and gas industry. Major shipping routes in the area are associated with entry to the ports of Dampier and Barrow Island. Shipping activities in the region include:

- international bulk freighters/tankers arriving and departing from Dampier, including mineral ore, hydrocarbons and salt carriers
- domestic support/supply vessels servicing offshore facilities and Barrow Island development
- construction vessels/barges/dredges
- offshore survey vessels.

No designated shipping fairways pass through the Operational Area.

4.5 Sensitive Marine Environments

The offshore environment of the NWS province contains environmental assets 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 Island group and the associated resident, temporary or migratory marine life including species such as marine mammals, turtles and birds. The marine environment of these offshore locations is pristine and many sensitive receptor locations are protected as part of Commonwealth and State managed areas.

The NRC Operational Area does not overlap with any established or proposed MPAs. The MPAs in close proximity to the operational area are the Montebello Commonwealth Marine Reserve, Montebello Islands Marine Park/ Barrow Island Marine Management Area and Lowendal Islands Nature Reserve. A summary of the existing and proposed State and Commonwealth MPAs of relevance to the Operational Area are presented in

.

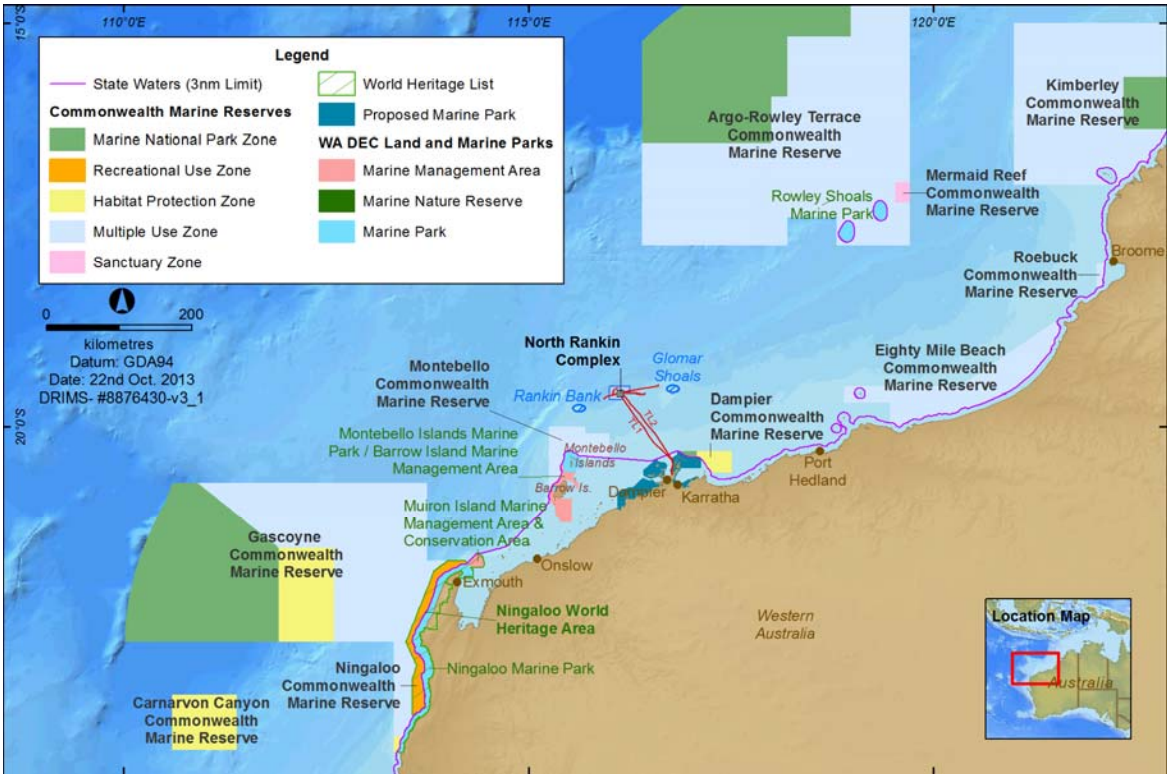


Figure 4-1: Established and proposed Commonwealth and State MPAs in relation to the NRC

Table 4-1Summary of Established and Proposed MPAs and other sensitive locations

	Distance from NRC Operational Area boundary (km)
State Marine Parks and Reserves	
Established Marine Parks and Reserves	
Montebello Islands Marine Park/ Barrow Island Marine Management Area (jointly managed)	~ 106 km
Lowendal Islands Nature Reserve	~ 130 km
Rowley Shoals Marine Park	~ 357 km
Muiron Islands Marine Management Area*	~ 290 km
Ningaloo Marine Park*	~ 290 km
Abrohlos Islands Nature Reserve	>1000 km
Proposed	
Dampier Archipelago Marine Park	~107 km
Commonwealth Marine Parks and Reserves	
Established	
Montebello Commonwealth Marine Reserve	~ 56 km
Dampier Commonwealth Marine Reserve	~ 107 km
Ningaloo Commonwealth Marine Reserve and World Heritage Area	~ 307 km
Mermaid Reef Marine Commonwealth Marine Reserve	~ 443 km
Gascoyne Commonwealth Marine Reserve	~ 280 km
Argo-Rowley Terrace Commonwealth Marine Reserve	~ 205 km
Shark Bay Commonwealth Marine Reserve and World Heritage Area	~ 630km
Abrohlos Commonwealth Marine Reserve	~ 893 km
Other	
Rankin Banks	~55 km
Glomar Shoal	~65 km
Northern, Middle and Southern Island Groups ‡	~132 to ~ 217 km
Exmouth Gulf	~336 km

5. ENVIRONMENTAL IMPACTS AND RISKS

5.1 Risk Identification and Evaluation

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

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

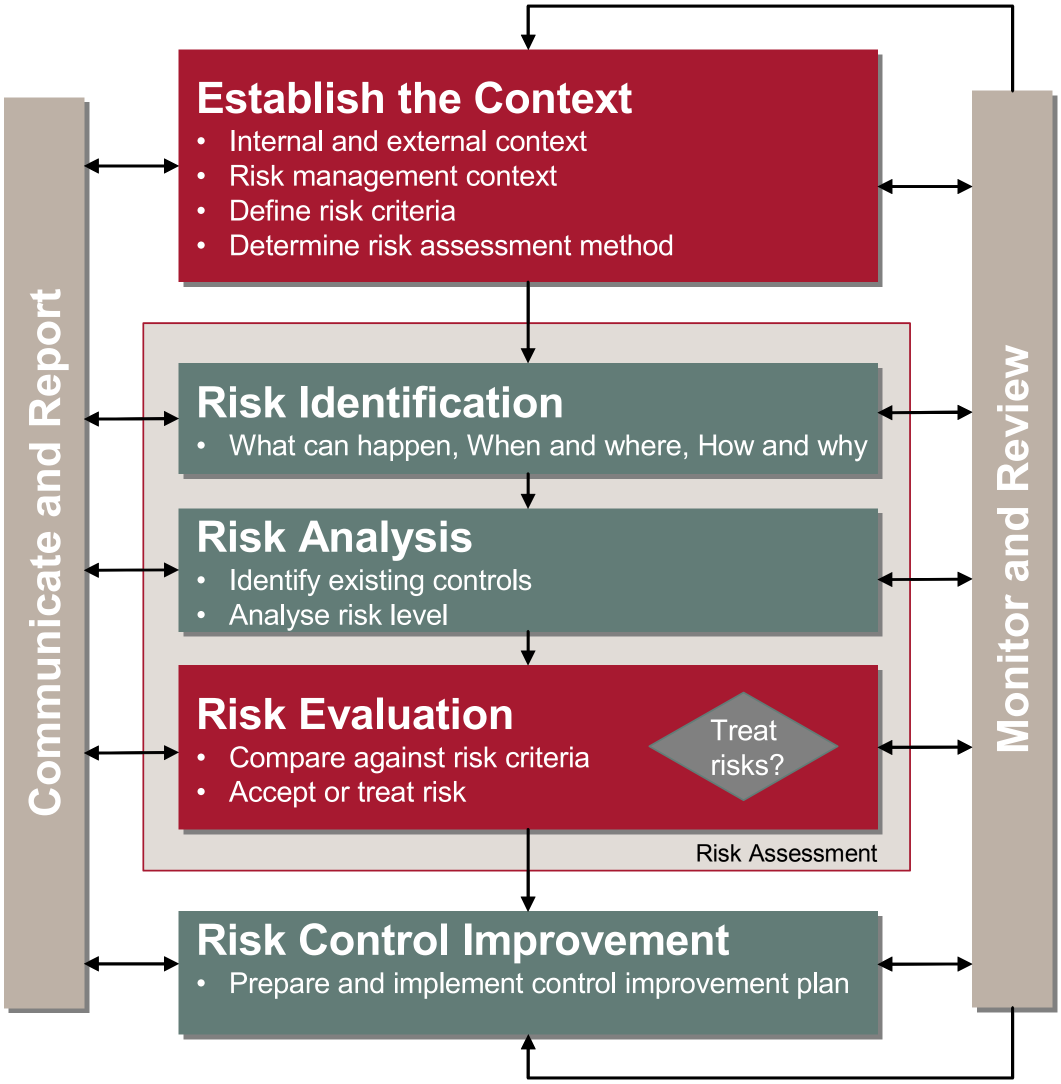


Figure 5-1: Key steps in Woodside's risk management framework

5.1.1 Establish the Context

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

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

5.1.2 Risk Identification

The risk assessment workshop for the Petroleum Activities Program was used to identify risks with the potential to harm the environment. Risks were identified for both planned (routine and non-routine) and unplanned (accidents/incidents) activities. Potential environmental impacts were then determined based on the stressor type.

5.1.3 Risk Analysis

Risk analysis further develops the understanding of a risk by defining the impacts and assessing the appropriate controls. Risk analysis for the Petroleum Activities Program considered previous risk assessments, 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 NRC risk assessment:

- identification of decision type in accordance with the Decision Support Framework
- identification of appropriate preventative and mitigation control measures
- calculation of the residual risk rankings
- classification and analysis of Major Environment Events (MEEs).

Decision Support Framework

To support the risk assessment process, Woodside applied the Guidance on Risk Related Decision Making (Oil and Gas UK 2014) during the workshops to determine the level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk is acceptable and ALARP.

This is to ensure:

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

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.

Risk rating process

The 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 residual risk (i.e. risk with controls in place) and is therefore undertaken following the identification of the decision type and appropriate control measures.

The risk rating process considers the environmental impacts and where applicable, the reputational/brand, and social/cultural impacts of the risk. The risk ratings are assigned using Woodside's Operational Risk Rating Tables (**Figure 5-2** and **Figure 5-3**).

The risk rating process is performed using the following steps:

- **Select the Consequence Level**
  - determine the most credible impacts associated with the selected event assuming some controls (prevention and mitigation) have failed. Where more than one impact applies (i.e. environmental and legal/compliance), the consequence level for the highest severity impact is selected
- **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
- **Select the Residual Risk Rating**
  - the residual risk rating is then determined by multiplying the selected consequence and likelihood levels: Residual Risk Level = Highest Selected Consequence Level x Selected Likelihood Level.

Woodside Operational Risk Tables

consequence table

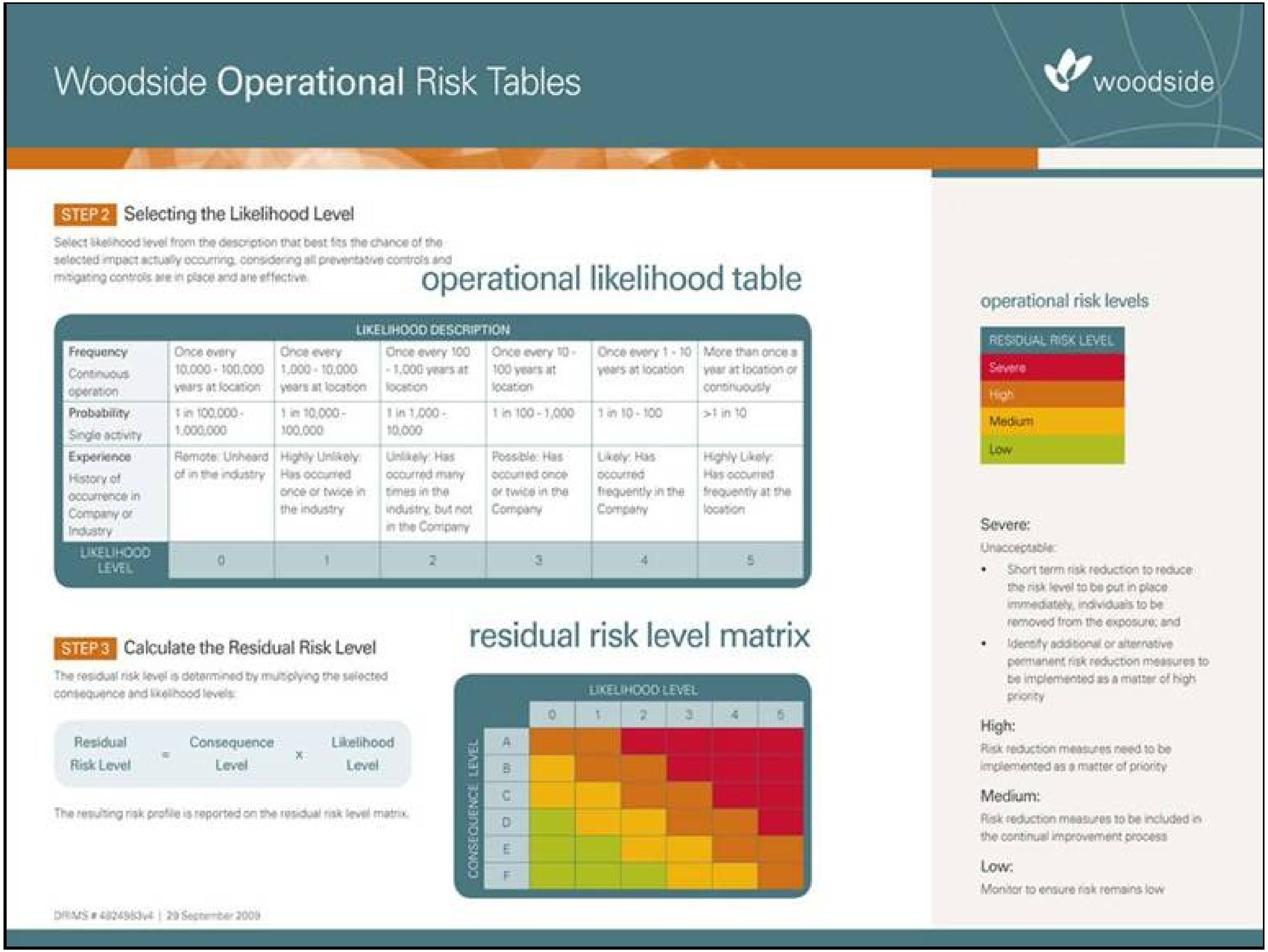
STEP 1 Selecting the Consequence Level

Describe the risk event being assessed. From the impacts listed in the consequence table select the most credible impacts associated with the selected event assuming preventative controls have failed. Where more than one impact applies, select the consequence level for the highest severity impact selected.

IMPACTS						CONSEQUENCE LEVEL
Health and Safety	Environment	Financial	Reputation & Brand	Legal/ Compliance	Social & Cultural	
>30 Fatalities or Permanent Total Disabilities	Permanent impact. Impact on highly valued ecosystems, species or habitat	>A$10B	International concern. Major ventures terminated. Company at stake	Potential jail terms for executives, directors or officers. Very high fines. Prolonged litigation seeking massive compensation	Permanent long term impact to a community or social infrastructure or highly valued areas/ items of international cultural significance	A
Multiple fatalities or Permanent Total Disabilities	Serious, long term (>10 years) impact. Impact on highly valued ecosystems, species or habitat	A$1B - $10B	Persistent national concern. Long term 'brand' impact. Major venture or asset operations severely restricted	Very significant fines and prosecutions. Very serious litigation	Serious, long term (>10 years) impact to the community, social infrastructure or highly valued areas/ items of national cultural significance	B
Single fatality or Permanent Total Disability	Major, long term (5 - 10 years) impact. Impacts on ecosystems, species or habitat	A$100M - $1B	Medium term national concern. Minor venture or minor asset operations restricted or curtailed	Serious breach of legislation, regulation or contract. Major litigation	Major long term (>10 years) impact to a community or social infrastructure or highly valued areas/ items of cultural significance	C
Major injury or Occupational Illness, Permanent Partial Disability or Lost Work Case >4 days	Moderate, medium term (2 - 5 years) impacts but not effecting ecosystem function	A$10M - $100M	National bad mention. Short term regional concern. Close scrutiny of Asset level operations or future proposals	Breach of legislation, regulation, contract or licence condition with investigation, or report to authority with prosecution and/ or moderate fine possible	Moderate, medium term (5 – 10 years) impact to a community or highly valued areas/ items of cultural significance	D
Moderate Injury/ Occupational illness. Restricted Workday Case or Lost Work Case <4 days or Medical Treatment Case	Minor, short term (1 – 2 years) impacts but not effecting ecosystem function	A$1M - $10M	Short term local concern. Some impact on asset level non-production activities	Breach of legislation, regulation, contract or licence condition; or regulatory action	Minor, short term (<5 years) impact to a community or areas/ items of cultural significance	E
First Aid Case	Slight, and temporary (<1 year) localised effect to ecosystem, species or habitat	< $1M	Isolated and short term local concern	Breach of internal standard	Minor, temporary impact to a community or areas/ items of cultural significance	F

DRIMS # 4824983v4 \| 29 September 2009

Figure 5-2: Woodside Operational Risk Consequence Table



Woodside Operational Risk Tables

STEP 2 Selecting the Likelihood Level

Select likelihood level from the description that best fits the chance of the selected impact actually occurring, considering all preventative controls and mitigating controls are in place and are effective.

operational likelihood table

	LIKELIHOOD DESCRIPTION					
Frequency Continuous operation	Once every 10,000 - 100,000 years at location	Once every 1,000 - 10,000 years at location	Once every 100 - 1,000 years at location	Once every 10 - 100 years at location	Once every 1 - 10 years at location	More than once a year at location or continuously
Probability Single activity	1 in 100,000 - 1,000,000	1 in 10,000 - 100,000	1 in 1,000 - 10,000	1 in 100 - 1,000	1 in 10 - 100	>1 in 10
Experience History of occurrence in Company or Industry	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 in the Company	Possible: Has occurred once or twice in the Company	Likely: Has occurred frequently in the Company	Highly Likely: Has occurred frequently at the location
LIKELIHOOD LEVEL	0	1	2	3	4	5

STEP 3 Calculate the Residual Risk Level

The residual risk level is determined by multiplying the selected consequence and likelihood levels:

Residual Risk Level = Consequence Level x Likelihood Level

The resulting risk profile is reported on the residual risk level matrix.

residual risk level matrix

CONSEQUENCE LEVEL	LIKELIHOOD LEVEL					
	0	1	2	3	4	5
A	🟧	🟧	🟥	🟥	🟥	🟥
B	🟨	🟧	🟧	🟥	🟥	🟥
C	🟨	🟨	🟧	🟧	🟥	🟥
D	🟩	🟨	🟨	🟧	🟧	🟥
E	🟩	🟩	🟨	🟨	🟧	🟧
F	🟩	🟩	🟩	🟨	🟨	🟧

operational risk levels

RESIDUAL RISK LEVEL
🟥 Severe
🟧 High
🟨 Medium
🟩 Low

Severe:

Unacceptable:

- Short term risk reduction to reduce the risk level to be put in place immediately, individuals to be removed from the exposure; and
- Identify additional or alternative permanent risk reduction measures to be implemented as a matter of high priority

High:

Risk reduction measures need to be implemented as a matter of priority

Medium:

Risk reduction measures to be included in the continual improvement process

Low:

Monitor to ensure risk remains low

DRIMS # 4824983v4 | 29 September 2009

Figure 5-3: Woodside Operational Risk Likelihood Table

Classification and Analysis of MEEs

For Woodside's Offshore Production Facilities a further level of analysis is undertaken to identify, classify and analyse Major Environmental Events (MEEs). This extra level of rigour is applied to ensure sufficient controls are in place for high consequence risks. In the health and safety area Major Accident Events (MAE) are identified using a similar process. MEE are defined by Woodside as:

- those events with potential Environment, Reputation, Social or Cultural Consequences of Category C or higher (as per Woodside's Operational Risk Matrix), which are evaluated against credible worst case scenarios which may occur when all controls are absent or have failed.

5.1.4 Risk Evaluation

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

Demonstration of ALARP

In accordance with Regulation 10A(b) of the Environment Regulations, Woodside demonstrates risks are reduced to ALARP where:

- the residual risk is low:
  - good industry practice or comparable standards have been applied to control the risk. Any further effort towards risk reduction is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained
- the residual risk is medium or high:
  - good industry practice is applied for the situation/risk, or
  - alternatives have been identified and the control measures selected reduce the risks and impacts to ALARP. This may require assessment of Woodside and industry benchmarking, review of local and international codes and standards, consultation with stakeholders etc.

Demonstration of Acceptability

In accordance with the Environmental Regulations, Woodside applies the following process to demonstrate acceptability:

- Low residual risks are 'Broadly Acceptable', if they meet legislative requirements and industry codes and standards
- Medium and High residual risks are 'Acceptable' if ALARP can be demonstrated using good industry practice, risk based analysis, consideration of company and societal values and if the alternative control measures are disproportionate to the benefit gained
- Severe residual risks are 'Intolerable' and therefore unacceptable. Risks will require further investigation and mitigation to reduce the risk to a lower and more acceptable level.

5.1.5 Risk Control Improvement

Where the level of risk is intolerable and therefore unacceptable, or the controls are not achieving the intended performance objectives, control improvement actions are identified, assigned and recorded in the NRC Environmental Risk Register.

Within the Production Division, risk control improvement is achieved by setting environmental targets, developing plans to achieve the targets and periodically reviewing performance.

For the NRC, control improvement occurs through a process of:

- establishing performance objectives for each identified risk
- defining the standards and controls that will be applied to achieve the objectives
- identifying measurement criteria that will be used to determine the effectiveness of the controls.

5.2 Hydrocarbon Spill Risk Assessment Methodology

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

5.2.1 The Zone of Consequence and Hydrocarbon Contact Thresholds

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

Surface fate and shoreline accumulation concentrations are expressed as grams per square metre (g/m^2), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb). Hydrocarbon thresholds are presented in the table below (**Table 5-1**) and described in the following subsections.

Table 5-1: Summary of thresholds applied to the quantitative hydrocarbon spill risk modelling results

Surface Hydrocarbon (g/m^2)	Entrained hydrocarbon (ppb)	Dissolved aromatic hydrocarbon (ppb)	Accumulated Hydrocarbon (g/m^2)
10	500	500	>100

Surface Hydrocarbon Threshold Concentrations

The spill modelling outputs were used to define the ZoC for surface hydrocarbon spills (contact on surface waters) using the ≥10 g/m^2 (dull metallic colours) based on the relationship between film thickness and appearance (Bonn Agreement 2009). 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, National Oceanic and Atmospheric Administration 1996).

Entrained Hydrocarbon Threshold Concentrations

The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data. 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 oil hydrocarbons. A conservative entrained threshold concentration of 500 ppb has therefore been adopted.

Dissolved Aromatic Hydrocarbon Threshold Concentrations

The threshold concentration value for dissolved aromatic hydrocarbons has been set with reference to results Woodside-commissioned ecotoxicity tests on NWS condensate. The NWS condensate sample provided for this analysis was collected from the NRC trunkline in Karratha. 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.

Based on these ecotoxicology tests, the selected dissolved aromatic hydrocarbon threshold of 500 ppb has been adopted. It is considered reasonable that the 500 ppb threshold remains applicable and appropriate for delineating potential chronic and acute effects to ecosystems, with the assessment recognising the potential for impact to reproductive success and early life stages of the most sensitive species at the adopted threshold value.

Accumulated Hydrocarbon Threshold Concentrations

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

6. ENVIRONMENTAL RISKS AND IMPACTS SUMMARY

Table 6-1 presents a summary of the sources of risk, analysis and evaluation for the Petroleum Activities program, using the methodology described above in **Section 5** of this EP Summary. There are two types of environmental risk sources identified for the Petroleum Activities Program which relate to activities which are planned and either undertaken on a routine or non-routine basis or which may occur from unplanned activities were also identified. These sources of risk range from small scale chemical spills with a low environmental consequence to hydrocarbon spill events with high environmental consequence.

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

Table 6-1: Environmental Risk and Impacts Register Summary

Source of Risk	Areas of Impact / Environmental Impacts	Residual Risk Rating				MEE Classification
		Consequence	Potential Consequence level of impact	Likelihood	Residual Risk	
Planned Activities (Routine and Non-routine)						
Physical presence						
Light emissions from platform and support vessels	• disturbance to marine fauna, particularly seabirds, marine turtles and fish.	F	Environment – Slight and temporary localised effect on species	1	Low	No
Noise emissions during routine operations	• disturbance to marine fauna, particularly whales, marine turtles and fish, potentially as direct physical damage or as a behavioural effect.	F	Environment - - Slight and temporary localised effect on species	1	Low	No
Physical presence of the facility and support vessels	• exclusion of other users including shipping and fishing • collision with marine fauna resulting in injury or fatality • provision of artificial habitat.	E	Environment – Minor, short term impacts	1	Low	No
Physical footprint	• seabed disturbance including localised mortality/disturbance of benthos.	F	Environment - - Slight and temporary localised effect on benthic communities	1	Low	No
Routine Atmospheric Emissions						
Gas flaring during operations	• temporary reduction in air quality beyond localised area • contribution to global greenhouse gas emissions • visual impact from flare flame and possibly dark smoke.	F	Environment – Slight and temporary effect on local air quality	2	Low	No

Source of Risk	**Areas of Impact / Environmental Impacts**	**Residual Risk Rating**				**MEE Classification**
		Consequence	**Potential Consequence level of impact**	**Likelihood**	**Residual Risk**	
Emissions from fuel combustion	• contribution to global greenhouse gas emissions • consumption of non-renewable natural resources.	F	Environment – Slight and temporary effect on local air quality	1	Low	No
Fugitive emissions	• contribution to global greenhouse gas emissions • loss of non-renewable natural resources.	F	Environment – Slight and temporary decrease in local air quality	1	Low	No
Routine Discharges						
Discharge of hydrocarbons and chemicals during subsea operations and activities	• localised water column pollution • localised adverse effect to marine biota.	F	Environment – Slight and/or temporal decrease in water quality	1	Low	No
Discharge of PW	• acute and chronic toxicity to marine biota • accumulation of toxicants in sediments affecting biota • bioaccumulation of organic toxicants.	F	Environment – Slight and/or temporal decrease in water quality	3	Med	No
Discharge of sewage and putrescible wastes	• eutrophication of localised water column.	F	Environment – Slight and/or temporal decrease in water quality	1	Low	No
Discharge of cooling water	• alteration of physiological processes • toxic effect to biota.	F	Environment – Slight and/or temporal decrease in water quality	2	Low	No
Discharge of brine water	• alteration of physiological processes of marine biota.	F	Environment – Slight and/or temporal decrease in water quality	1	Low	No

Source of Risk	Areas of Impact / Environmental Impacts	Residual Risk Rating				MEE Classification
		Consequence	Potential Consequence level of impact	Likelihood	Residual Risk	
Discharge of drainage water	• localised water column pollution.	F	Environment – Slight and/or temporal decrease in water quality	2	Low	No
Waste Management and Chemical Use						
Hazardous and nonhazardous waste handling and disposal	• pollution and contamination of the environment • secondary impacts on marine fauna (e.g. entanglement).	F	Environment – Slight and/or temporal decrease in water quality	1	Low	No
Release of NORMs	• pollution of the marine environment and potentially chronic and acute toxicity impacts on marine flora and fauna • pollution of the terrestrial environment and potentially chronic and acute toxicity impacts on terrestrial flora and fauna.	E	Environment – Slight and/or temporal decrease in water quality and terrestrial environment	1	Low	No
Chemical selection and use	• localised water column pollution • localised adverse effect to marine life.	F	Environment – Slight and/or temporal decrease in water quality	2	Low	No
Unplanned Activities (accidents / incidents)						
Invasive Marine Species						
Introduction of invasive marine species	• introduction of invasive marine species, possibly resulting in alteration of the natural ecosystem.	E	Environment – Slight and temporary localised effect on species	1	Low	Yes
Non-routine / Accidental Atmospheric Emissions						
Venting of hydrocarbon gases	• contribution to global greenhouse gas	F	Environment – Slight and temporary decrease in local air quality	2	Low	No

Source of Risk	Areas of Impact / Environmental Impacts	Residual Risk Rating				MEE Classification
		Consequence	Potential Consequence level of impact	Likelihood	Residual Risk	
	emissions					
Release of Synthetic Greenhouse Gases and Ozone-Depleting Substances	- ozone depletion and contribution to atmosphere of gases with high global warming potential and atmospheric lifetime.	F	Environment – Slight and temporary decrease in local air quality	1	Low	No
Non-routine / Accidental Hydrocarbon or Chemical Spills						
Chemical spill from platform and support vessels	- pollution of the marine environment - adverse effects on marine life (sea floor and open water).	F	Environment – Slight and/or temporary decrease in water quality.	2	Low	No
Hydrocarbon release during bunkering operations	- localised water column pollution - localised adverse effect to marine biota.	E	Environment – Slight and/or temporary decrease in water quality. Environment – Slight and temporary disruption to a small proportion of protected species.	2	Med	No
Hydrocarbon release caused by a well loss of containment	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and seagrass communities.	B	Environment – Large scale and long term environmental effects to sensitive biota and habitats. Recovery >10 years or permanent. Reputation/brand – Serious national and international concern, economic impact on commercial and recreational marine-based activities.	1	High	Yes
Hydrocarbon release caused by a subsea loss of containment	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and	B	Environment – Large scale and long term environmental effects to sensitive biota and habitats. Recovery >10 years or permanent. Reputation/brand – Serious national and international concern, economic impact on commercial and recreational marine-based	1	High	Yes

Source of Risk	**Areas of Impact / Environmental Impacts**	**Residual Risk Rating**				**MEE Classification**
		Consequence	**Potential Consequence level of impact**	**Likelihood**	**Residual Risk**	
	seagrass communities.		activities.			
Hydrocarbon release caused by a topsides loss of containment	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and seagrass communities.	C	Environment – Localised and long term effects to community/habitat structure and marine primary producers.	1	Med	Yes
Hydrocarbon release caused by a loss of structural integrity	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and seagrass communities.	B	Environment – Large scale and long term environmental effects to sensitive biota and habitats. Recovery >10 years or permanent. Reputation/brand – Serious national and international concern, economic impact on commercial and recreational marine-based activities.	1	High	Yes
Hydrocarbon release caused by loss of marine vessel separation	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and seagrass communities.	B	Environment – Large scale and long term environmental effects to sensitive biota and habitats. Recovery >10 years or permanent. Reputation/brand – Serious national and international concern, economic impact on commercial and recreational marine-based activities.	1	High	Yes
Hydrocarbon release caused by loss of suspended load	- biological and ecological impacts to megafauna, plankton, deepwater benthic communities, offshore fish species, fisheries, coral reefs, mangroves, subtidal flats and sandy beaches and seagrass communities.	B	Environment – Large scale and long term environmental effects to sensitive biota and habitats. Recovery >10 years or permanent. Reputation/brand – Serious national and international concern, economic impact on commercial and recreational marine-based activities.	1	High	Yes

7. ONGOING MONITORING OF ENVIRONMENTAL PERFORMANCE

The Petroleum Activities Program will be managed in compliance with the NRC 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 NRC Operations 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 a statement of performance required of a control (available in **Appendix A**) that will be implemented 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 NRC 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.

Woodside and its contractors will undertake a program of periodic monitoring during the Petroleum Activities Program, starting at mobilisation of each activity and continuing through the duration of each activity until activity completion. This information is collected using appropriate tools and systems, based on the environmental performance outcomes, performance standards and measurement criteria in the NRC Operations EP.

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:

- Environmental Performance Report will be submitted to NOPSEMA annually within twelve months of commencement of the activity to assess and confirm compliance with the accepted environmental performance objectives, standards and measurement criteria outlined in the NRC Operations EP
- Activity-based inspections undertaken by Woodside's environment function to review compliance against the NRC Operations EP, verify effectiveness of the implementation strategy and to review environmental performance
- Environmental performance is also monitored daily via daily progress reports during operations
- Senior management regularly monitors and reviews environmental performance via a monthly report which details 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 NRC Operations 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.

The NRC Operations EP is supported by an assessment of the environmental impacts and risks associated with potential hydrocarbon spill scenarios and hydrocarbon spill preparedness and response measures in relation to the risk assessment and the identified hydrocarbon spill scenarios. A summary of Woodside's response arrangements in the OPEP is provided in **Appendix B**.

7.1 Environment Plan Revisions and Management of Change

Revision of the NRC Operations EP will be undertaken in accordance with the requirements outlined in Regulations 17, 18 and 19 of the Environment Regulations. Woodside will submit a revision to the EP due to all or any of the following:

- When any significant modification or new stage of the activity that is not provided for in the NRC Operations EP
- 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 NRC Operations EP
- At least 14 days before the end of each period of 5 years commencing on the day on which the original and subsequent revisions of the EP is accepted under Regulation 11 of the Environment Regulations
- As requested by NOPSEMA.

Management of changes relevant to the NRC Operations EP, concerning the scope of the activity description including review of advances in technology at stages where new equipment may be selected such as vessel contracting, changes in understanding of the environment, including all current advice on species protected under EPBC Act and current requirements for Commonwealth Marine Reserves 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 NRC 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 NRC 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 NRC 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 NRC 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

Woodside's Oil Pollution Emergency Plan (OPEP) for the Petroleum Activities Program has the following components:

- Oil Pollution Emergency Arrangements (Australia)
- North Rankin Complex Facility Oil Pollution First Strike Plan
- Oil Spill Preparedness and Response Mitigation Assessment for NRC Operations.

8.1 Woodside Oil Pollution Emergency Arrangements (Australia)

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

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

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

All 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 NRC. Training includes task specific training and role based training. Oil spill task specific training is typically undertaken at the Australian Marine Oil Spill Centre (AMOSC) Geelong facility, whereas role based training includes a combination of courses (i.e. Command and Control) and 'on the job' experience (i.e. participation in crisis or emergency management exercises).

The Corporate Incident Coordination Centre (CICC), based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency or crisis. The CICC is staffed by an appropriately skilled team 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. In order 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. 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 North Rankin Complex Facility Oil Pollution First Strike Plan

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

The activity vessels will have Ship Oil Pollution Emergency Plans (SOPEPs) in accordance with the requirements of 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 North Rankin Complex Facility Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs.

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

8.3 Oil Spill Preparedness and Response Mitigation Assessment

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

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

- **Monitor and Evaluate** – gathering of data 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 operational monitoring plans to satisfy the requirements of this mitigation control. Further information on monitoring is provided in **Section 8.4**
- **Source Control (well control and intervention)** – Woodside's strategy is to minimise the volume of hydrocarbons released from an oil spill event. Woodside plans to deploy the following controls specific to well loss of containment scenarios, if required for the Petroleum Activities Program:
  - SFRT deployment to clear debris, assess the well at the sea bed, and if practicable, attempt to close the emergency blowout preventer
  - source control (deployment of capping stack)
  - well intervention (relief well drilling)
- **Open Water Containment and Recovery** – Involves the physical containment and mechanical removal of hydrocarbons from the marine environment. Suitable vessels would be drawn from Woodside's integrated fleet, other operators in the region and from the charter market. Open water containment and recovery equipment (e.g. booms and skimmers) would be sourced from Woodside's own equipment, the Australian Maritime Safety Authority (AMSA), AMOSC and Oil Spill Response Limited (OSRL) stockpiles
  - **Shoreline Protection** – Shoreline protection and deflection equipment would be deployed either from a vessel or from the shore, depending on the prevailing conditions, shoreline type and access. Additional resources would be mobilised

depending on the scale of the event to increase the number of shorelines being protected

  - **Shoreline Clean-up** – Shoreline clean-up may be undertaken to remove hydrocarbons and monitor effectiveness of clean-up activities. There are different manual and mechanical shoreline clean-up techniques and the appropriate techniques will be selected based on the different shoreline types and conditions

- **Oiled wildlife response** – Staging sites will be established for shoreline or vessel based oiled wildlife response teams. Once recovered to a staging site, wildlife will be transported to the designated oiled wildlife facility for stabilisation and treatment.

To support the above response strategies, Woodside has access to Veolia's waste management facilities as well as waste storage equipment from AMOSC, AMSA and OSRL.

Implementation of these response strategies would be re-assessed during a spill event, with consideration of the size of spill, weather conditions and other constraints.

A summary of potential risks; potential impacts and control measures for oil spill response during the Petroleum Activities Program is included in **Appendix B.**

8.4 Monitoring

8.4.1 Operational Monitoring

To gain an understanding of the spill event, its movement and to direct mitigation activities to the optimal locations, 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
- monitoring of contaminated resources and the effectiveness of response and clean-up operations.

8.4.2 Scientific Monitoring

Woodside would activate its Scientific Monitoring Program (SMP) following a Level 2 or 3 hydrocarbon release, or any release event with the potential, or actual, contact to sensitive environmental receptors. The nature and scale of the spill event would dictate the implementation and operational timing of the SMP. Ten targeted scientific monitoring programs may be implemented to address a range of physical-chemical (water and sediment) and biological receptors (species and habitats) including EPBC Act listed species, environmental values associated with Protected Areas and socio-economic values such as fisheries. When activated the Woodside SMP has the following objectives:

- Assess the extent, severity and persistence of the environmental impacts associated with the hydrocarbon release and the response activities
- Monitor the subsequent recovery of impacted key species, habitats and ecosystems
- Acquisition of pre-emptive baseline data required to support the post-response SMP in monitoring, evaluating and documenting the recovery of impacted environmental receptors.

9. CONSULTATION

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

The consultation process undertaken for the NRC Operations EP was as follows:

- Woodside conducted a stakeholder assessment based on the activity location, timing and potential impacts.
- Distribute consultation fact sheet to identified stakeholders;
- Encourage identified stakeholders to distribute consultation fact sheet to other interested parties;
- Publish consultation fact sheet on Woodside website; and
- Provide 1800 toll free number on the consultation fact sheet.

The consultation fact sheet was sent electronically to all stakeholders identified through the stakeholder assessment process prior to lodgement of the NRC Operations EP with NOPSEMA for assessment and acceptance. The original factsheet was sent on the 18th July 2013 with an activity update (Start-up and Operation of the Persephone field), sent on the 12th June 2016. In addition 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 facility (or their nominated representative) or have a State or Commonwealth regulatory role.

Table 9-1: Relevant stakeholder identified for the Petroleum Activities Program

Stakeholder	Relevance
Department of Industry	Department of relevant Commonwealth Minister
DMP	Department of relevant State Minister
AMSA (maritime safety)	Maritime safety
Australian Fisheries Management Authority	Commercial fishery management
Department of Fisheries (Western Australia)	Fisheries management
Commonwealth Fisheries: Western Tuna and Billfish; Western Skipjack Tuna Fishery; and Southern Bluefin Tuna.	Commercial fishery – Commonwealth
Western Australian Fisheries Western Australian Mackerel Fishery. Pilbara NCDSF Fishery Onslow Prawn Fishery	Commercial fishery – State
Department of Transport (Western Australia)	Marine pollution response

Woodside also made available advice about the Petroleum Activities Program to other stakeholders who may be interested in the activity or who have previously expressed an interest in being kept informed about Woodside's activities in the region. Stakeholders that have been identified as 'interested' in the Petroleum Activities Program are listed in **Table 9-2**.

Table 9-2: Interested stakeholders identified for the NRC Operations EP

Organisation	Interest
Department of Environment	Matters of National Environmental Significance and Department of Commonwealth Environment Minister
Department of Parks and Wildlife	State environment and wildlife
AMSA (marine pollution)	Commonwealth marine pollution response
Australian Customs Service – Border Protection Command	Boarder protection
Commonwealth Fisheries Association	Commercial fishery representation
Western Australian Fishing Industry Council	Commercial fishery representation
Pearl Producers Association	Pearl fishery representative
RecfishWest	Recreational fishery representation
World Wildlife Fund	Non-government organisations (environment)
Australian Conservation Foundation	Non-government organisations (environment)
Wilderness Society	Non-government organisations (environment)
International Fund for Animal Welfare	Non-government organisations (environment)
Australian Petroleum Production and Exploration Association	Oil and gas industry representation

Woodside received feedback on the Petroleum Activities Program from a range of stakeholders, including government agencies and commercial fishing organisations. Issues of interest or concern included the location of the activities across commercial fishing areas. Woodside considered this feedback in its development of control measures specific to the Petroleum Activities Program. A summary of feedback and Woodside's response is presented in **Appendix C.**

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 NRC Operations EP. Stakeholder feedback should be made to the nominated liaison person, identified in **Section 10** of this EP Summary.

9.2 Non-Routine Events

Woodside recognises that the relevance of stakeholders identified in this 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 this EP may be affected.

Stakeholder groups include:

- Emergency response organisations;
- Government agencies with responsibilities for the resource development, environment; fisheries, tourism, border protection and defence;
- Government Ministers;
- Local governments, including representation local communities (Shire of Roebourne);
- Pastoral lease holders;
- Marine tourism operators;
- Commonwealth and State fisheries;
- Charter boat operators;
- Other petroleum operators;
- Other industry;
- Development Commissions and Industry Associations;
- Aboriginal claimant groups and representative organisations; and
- Non-Government Organisations.

10. TITLEHOLDER NOMINATED LIAISON PERSON

For further information on this Petroleum Activities Program, please contact:

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11. ABBEVIATIONS

Term	Description / Definition
1TL	First trunkline
2TL	Second trunkline
ALARP	As Low As Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
CCR	Central Control Room
DEH	Department of Environment and Heritage
DMP	Department of Mines and Petroleum
DP	Dynamic Positioning
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act, 1999*
Environment Regulations	*Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations* 2009 (Cth)
GWA	Goodwyn Alpha
HP	High Pressure
ICS	Incident Command Structure
IFL	Inter-field Flow Line
IMR	Inspection, Maintenance and Repair
ITF	Indonesian Throughflow
KEF	Key Ecological Feature
KGP	Karratha Gas Plant
KO	Knock Out
LP	Low Pressure
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973
MAE	Major Accident Event
MEE	Major Environmental Event
MoU	Memorandum of Understanding
MPA	Marine Protected Area
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NRA	North Rankin A
NRB	North Rankin B
NRC	North Rankin Complex
NRC Operations EP	North Rankin Complex Facility Operations Environment Plan
NWMR	North West Marine Region
NWS	North West Shelf

OPEP	Oil Pollution Emergency Plan
OSRL	Oil Spill Response Limited
PoB	Persons Onboard
Ppb	Parts Per Billion
PW	Produced Water
ROV	Remote Operated Vehicle
SFRT	Subsea Frist Response Toolkit
SMP	Scientific Monitoring Program
SOPEP	Ship Oil Pollution Emergency Plan
SCSSV	Surface Controlled Subsea Safety Valve
SSSV	Sub-Surface Safety Valve
Woodside	Woodside Energy Ltd
ZoC	Zone of Consequence

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APPENDIX A: DETAILED ENVIRONMENTAL IMPACTS AND RISKS

PLANNED ACTIVITIES (ROUTINE AND NON-ROUTINE)

A- 1 Physical Presence: Light Emissions from Platform and Support Vessels

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Platform Lighting • Support Vessel Operations • Operational Flaring • Subsea Inspection, Maintenance and Repair Activities.						X				F	1	Low

Description of Source of Risk

The platform and support vessels have adequate lighting to allow safe working conditions during 24 hour operations. Unless required to support over the side activities (such as lifting operations or IMR activities), lighting on the platform and support vessels is directed to the work area, which aids in limiting light spill to sea. During IMR activities underwater lighting is generated over short periods of time while ROVs are in use. Flaring can also contribute to light being emitted from the facility. Additional lighting may be required as part of the Persephone topside modifications to provide safe working conditions on the facility.

The environmental risk is light emitted from the facility and support vessels causing disturbance to marine fauna. The marine species with greatest sensitivity to light are seabirds and turtles.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Protected Species	**Seabirds and Migratory Birds** Weise et al (2001) presented a literature review regarding the effect of light from platforms in the Northwest Atlantic on seabirds. They noted that seabirds are highly 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 occur through direct collisions and the rate of collision is (as inferred from literature) related to weather conditions, the cross-sectional area of the obstacle, amount of light and number of birds travelling through an area. Where bird collision incidents have been reported, low visibility weather conditions (cloudy, overcast and foggy nights) are usually implicated as the major contributing factor and there are seldom collision incidents on clear nights (Avery, 1976; Elkins, 1988; Weisse et al, 2001). Conditions in the region are not conducive to fog formation and wet weather is infrequent, with most rainfall associated with cyclones in January to March which is outside the period of bird migration (southward migration is from August to November, and northward migration from March to May). Black (2005) reported on two cases of mass seabird mortalities from striking ships in the Southern Ocean (the Aurara Australis and the Dorade). In both cases, mortality incidents occurred when the vessels were at anchor near seabird colonies and conducting night deck operations, during periods of reduced visibility due to foggy weather conditions. Newly fledged juvenile birds leaving the breeding colony for the first time are the most prone to disorientation by nearby lighting (Commonwealth of Australia, 2012b). The Montebello Islands and islands of the Dampier Archipelago, located 110 km or more away from the NRC, provide nesting and foraging habitats for some seabirds and waders. There are also areas of critical habitat for seabirds in the broader region including offshore islands and the Ramsar Convention protected

sites at Eighty Mile Beach and Roebuck Bay. However, the NRC is located approximately 500 km or more from the closest of these locations.

The potential for seabirds colliding with the NRC due to disorientatation by lighting is therefore considered to be insignificant given the minimal light being directed outwards from the facility, the distance from nesting habitats and seabird colonies, and the prevalent clear visibility conditions.

In a study of offshore oil platforms in the North Sea, Poot et al (2008) demonstrated that large flocks of migrating seabirds can be attracted to the lights and flares of offshore oil platforms, particularly on cloudy nights and between the hours of midnight and dawn. They hypothesised that when such offshore platforms are located 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 significantly reduce the bird's resilience and potential survival. Migratory shorebirds travelling the East Asian-Australasian Flyway may transit through the NRC Operational Area en route to staging areas, before moving onto the mainland in the 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 NRC 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 platforms, they will not be facing long-distance journeys upon leaving the facility. The environmental impact associated with seabirds potentially attracted to the light, and hence diverted from their migratory pathway is considered to be insignificant.

Marine Turtles

The attraction of marine turtles to light has been well documented (for example, Salmon et. al, 1992 and Witherington and Martin, 2000). Disturbance can occur to adults during nesting or to newly emerged hatchlings. Disturbance to nesting adults is limited to light on or in very close proximity to the nesting beach and not discussed further. If hatchlings emerge from the nest at night, they use light cues to find their way to the ocean. Once in the water the exact methods of navigation are not fully understood, but it is known that hatchlings in the water are attracted to strong light sources.

The potential for turtle hatchlings to be attracted to the NRC Operational Area is mitigated by its distance from the nearest shoreline and offshore islands where turtle nesting may occur (approximately 135 km to both the Montebello Islands and Dampier Archipelago, which means that light generated from the NRC platforms would not be visible from ground level at the closest coastal location. The potential effect is also mitigated by minimal light being directed outwards from the facility and (in the case of support vessels) the movement of the vessel. Similarly, light generated by flaring is not expected to be visible from the nearest coastline such that there is no potential to disorient or disrupt natural turtle behaviour at the nearest coastal location. Waters around the NRC Operational Area are not a critical habitat for turtles and are distant from internesting areas. The environmental impact of turtles being attracted by the NRC operational activities is considered to be insignificant.

Fish

Lighting from activities in the NRC Operational Area may result in the localised aggregation of fish below the source of light. These aggregations of fish would be confined to a small area. Any long term changes to fish species composition or abundance in the NRC Operational Area resulting from light spill from the platforms and support vessel activities is highly unlikely.

Summary of Control Measures

Compliance with Offshore Facility Environment Inspection Report requirements:

- Inspections of light spill will be conducted at the facility to verify lighting is limited to that required for safe working conditions, with corrective actions implemented.

A- 2 Physical Presence: Noise Emissions During Routine Operations

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are general noise emitting machinery and processes, including: • Subsea Infrastructure • Process Description • Operational Flaring • Power Generation • Support Vessel Operations • Helicopter Operations • Subsea Inspection, Maintenance and Repair Activities						X				F	1	Low

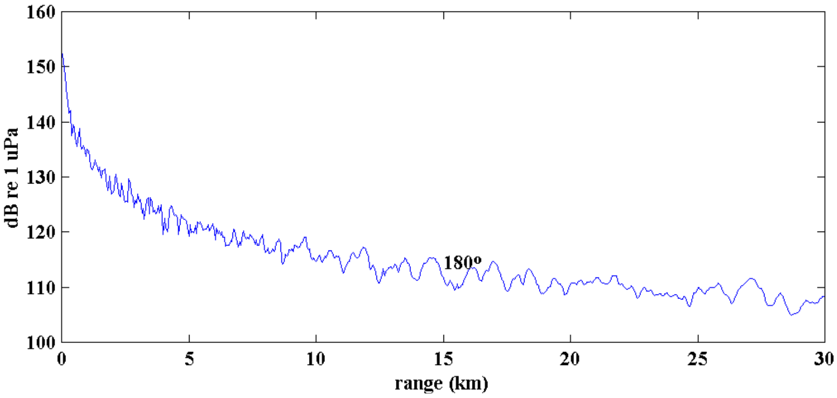
Description of Source of Risk

The environmental risk is noise emitted from the NRC causing disturbance to marine fauna. The facility, associated infrastructure and support vessels will emit noise from machinery, production process equipment and subsea activities. The NRC support vessels and helicopters will also create noise from engines and propellers.

Support Vessels

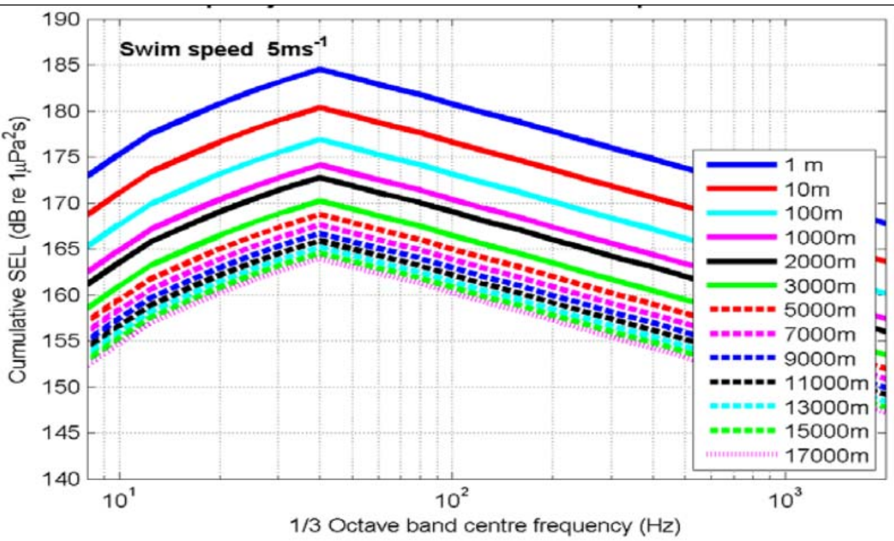
McCauley (1998) measured underwater broadband noise equivalent to approximately 182 dB re µPa at 1 m from a support vessel holding station in the Timor Sea. The noise level during this event far exceeded the noise produced by the same vessel when it was either underway or idling. The noise emitted by a support vessel holding station will be the most intense source of noise associated with the NRC infrastructure.

The received sound intensity weakens as the sound wave radiates from its source of origin. Using the measurements of support vessel noise McCauley (2003) estimated the transmission of underwater noise from a support vessel holding station to a receiver at 30 m depth.



Estimated transmission of underwater noise from a support vessel holding station (McCauley, 2003)

Theobald et al (2009) have calculated the cumulative sound exposure received by an animal approaching and swimming past a vessel with noise level of 182 dB re 1µPa @ 1 m (analogous to support vessel holding station). The maximum exposure is calculated to be 185 dB re 1 µPa2.s.



Calculated cumulative sound exposure level received by animal swimming past vessel with source noise level of 185 dB re 1 µPa2.s (trajectory length 30 km, swim depth 10 m, legend refers to separation distance at closest point) (Theobald et al, 2009)

Wellhead and Pipelines

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 (approximately less than 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 less than 200 m from the wellhead.

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

IMR Activities

Subsea activities are typically undertaken from vessels that use a DP system. This allows manoeuvrability and avoids anchoring when undertaking works in close proximity of subsea infrastructure. As the vessel will maintain its position with the continual use of DP thrusters, the thrusters will dominate as the source of underwater noise. Noise generated from these activities will be intermittent and of short duration.

Helicopters

The intensity of sound travelling from a source in the air (e.g. helicopter) to a receiver underwater is complex and depends on source altitude and lateral distance, receiver depth, water depth, and other variables. The angle at which the line from the aircraft and receiver intersects the water surface is important. In calm conditions, at angles greater than 13° from the vertical, much of the sound is reflected and does not penetrate into the water (Richardson et al, 1995). Therefore, strong underwater sounds are detectable for a period roughly corresponding to the time the helicopter is within a 26° cone above the receiver. Richardson et al, (1995) reported figures for a Bell 214 helicopter (stated to be one of the noisiest) being audible in air for 4 minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. The maximum received level was 109 dB re 1µPa2.s.

Facility Machinery

Production facilities have machinery mounted on decks raised above the sea; hence most noise is transmitted to the marine environment from air. As noted in the discussion for helicopters (above), at angles greater than about 13 degrees from the vertical much of the sound is reflected and does not penetrate into the water. Assuming a conservative maximum 20 degree angle of penetration, the maximum distance from the facility at which machinery noises could be transmitted into the water column is about 15 to 20 m.

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Protected Species	The species with greatest sensitivity to underwater noise are whales, turtles and fish. Two pathways of effect are considered - direct physical damage and behavioural effect. **Physical damage**

Whales: The potential for physical damage to whales from noise, such as hearing loss, is limited to circumstances when individuals are in close proximity to an intense sound from high energy sources. For baleen whales, the threshold for physical injury (defined as the onset of permanent threshold shift) from pulse and non-pulse sources has been estimated by Southall et al (2007) as occurring at the received Sound Exposure Levels (SELs) of 198 and 215 dB re 1µPa2.s, respectively. The approach of Southall et al (2007) recognises that even if the initial received levels are not great enough to cause injury, harmful effects can result from lower level sounds which last for a longer duration.

The EPBC Seismic Interaction Guidelines DEWHA (2008) use the lower standard of 160 dB re 1µPa2.s from a single pulse at 1 km, on the assumption that the whale would receive the multiple pulses for a 30 minute period (leading to a cumulative SEL of 183 dB re 1µPa2.s, the threshold for temporary threshold shift).

Comparison to the thresholds for physiological damage indicate that if a whale were to approach to within 10 m of a support vessel while the vessel was holding station it may receive cumulative SEL sufficient to experience temporary threshold shift, but would not receive cumulative SEL sufficient to cause permanent physiological damage. There are no activities that are predicted to result in sound intensity exceeding the threshold peak impulse sound pressure and hence there is no potential for direct physical trauma to cetaceans in the Operational Area.

Turtles: Marine turtles do not have an external hearing organ but can detect sound through bone conducted vibration in their skull and by using their shell as a receiving surface (Lenhardt et al, 1983). Electro-physical studies have indicated that the best hearing range for marine turtles is in the 100 to 700 Hz range. For turtles, the only known data addressing threshold shift is a study conducted by Eckert et al (2006) on leatherback turtles. This study demonstrated that turtles will suffer temporary threshold shift and eventually permanent threshold shift from seismic impulses with SEL greater than 185 dB re 1 µPa2.s. A turtle swimming past a support vessel holding station would need to pass within 1 m to receive cumulative SEL sufficient to cause physiological damage.

Fish: There is a wide range of susceptibility to noise pulses among fish species. The primary factor likely to influence susceptibility to noise is the presence or absence of a swim bladder. Generally fishes with a swim bladder will be more susceptible than those without. Many large fishes, including the elasmobranchs (sharks, rays and sawfish) do not possess a swim bladder and so are not susceptible to swim bladder-induced trauma. Using a similar approach to the DEWHA Policy Statement (DEWHA, 2008) and the derived relationship of Hastings and Popper (2005), threshold criteria for physiological harm to fish with a swim bladder has been calculated to be (assuming one pulse every 8 seconds resulting in a total of 75 pulses over a ten minute period):

- For a 0.1 kg fish: single exposure of 199 dB re 1 µPa2.s; and
- For a 1 kg fish: single exposure of 200 dB re 1 µPa2.s.

It is unlikely that fish would receive cumulative SEL from the NRC Operational Area activities that is sufficient to cause physiological damage.

Behavioural Effects

Whales: Southall et al (2007) conducted a comprehensive review of published data describing behaviour of marine mammals in response to sound. They defined the threshold for behaviour response as being, “moderate changes in locomotion speed direction and/or dive profile but no avoidance of the sound source, brief minor shift in group distribution and moderate cessation or modification of vocal behaviour”. The review indicated no (or very limited) response to noise from cetaceans at received levels below 120 dB re 1 µPa, and an increasing probability of avoidance and other behavioural effects in the 120 to 160 dB re 1 µPa range. Contextual variables (such as proximity of source, novelty and operational features) in addition to received level may also affect response type and magnitude. Initial reactions by cetaceans to noise may (in some conditions) diminish with repeated exposure and individual experience. By reference to Figure 6 1, it can be inferred that whales may exhibit avoidance behaviour within approximately 5 km of a support vessel holding station at the NRC. Whales are unlikely to exhibit avoidance of the wellheads as result of underwater noise effects.

Given the Operational Area’s offshore location close to the northern margin of the migration route, the numbers passing within 5 km distance represent a small proportion of migrating whales. The potential for a behavioural response if approaching whilst a DP vessel is holding station is therefore likely to be limited to a few individuals. Noise generated from a DP support vessel at the facility is unlikely to result in a behavioural response in most migrating Humpback whales that are passing through the Operational Area. Similarly, pygmy blue whales are only expected infrequently in the vicinity of the NRC facility.

In 2010, WEL commissioned RPS (RPS, 2010) to undertake a Humpback whale monitoring study to determine whether there had been any changes in the humpback whale distribution in waters surrounding the Ngujima-yin and Nganhurra FPSO's since commissioning in 2008. The 2010 aerial surveys were undertaken seaward of the North West Cape, between the 20 m isobath out to the 1,000 m isobath, during the Humpback whale migration. The data was then compared to baseline survey monitoring data (2000 to 2001), the effort of which was considerably larger than the 2010 survey. The comparison of the data suggested there was no significant evidence of displacement of the distribution of humpbacks whales as a result of the operating facilities (RPS, 2010).

Turtles: Marine turtles have been recorded as demonstrating a startle response to sudden noises (Lenhardt et al, 1983). Captive experiments with green and loggerhead turtles showed behavioural responses (increased swimming activity) to an approaching single airgun (bolt 600B, 20 cui) at received sound levels of approximately 166 dB re 1 µPa (rms), and erratic behaviour (presumed leading to avoidance) at around 175 dB re 1µPa (rms) (McCauley et al, 2003). McCauley et al, (2000) found behavioural avoidance at 155 to 164 dB re 1 µPa2.s. Above a received airgun level of approximately 155 dB re 1 µPa2-s, the turtles began to noticeably increase their swimming speed. Above a received airgun level of approximately 164 dB re 1 µPa2-s the turtles began to show a more erratic swimming pattern, possibly indicative of a distressed state. However, there is no impulsive noise sources similar to seismic noise associated with the NRC facility operations, and such a response is less likely to occur with continuous noise sources such as vessel noise. By reference to Figure 6 1 it can be inferred that turtles may exhibit avoidance behaviour within approximately 50 m of a support vessel holding station, but are unlikely to exhibit avoidance of the NRC as a result of underwater noise effects.

Fish: Bony fish vary widely in their vocalisations and hearing abilities, but generally hear best at low frequencies below 1 kHz (Ladich, 2000). Behavioural effects of noise on fish may include changes to schooling behaviour and avoidance of the noise source (Simmonds and MacLennan, 2005). Available evidence suggests that behavioural change for some fish species may be no more than a nuisance factor. These behavioural changes are localised and temporary, with displacement of pelagic or migratory fish populations having insignificant repercussions at a population level (McCauley, 1994).

The hearing capabilities of the whale shark have not been studied, but it has been suggested that they are likely to be most responsive to low-frequency sounds (Myberg, 2001). Whale sharks have been observed to dive upon ignition of nearby inboard vessel motors, which may be a response to the low frequency sound signature of such motors (Myberg, 2001). The potential for behavioural response in whale sharks is likely to be confined to the immediate Operational Area and regional impacts to shark or other fish populations and their normal movements are unlikely.

Noise from helicopters are highly transient and within the bounds of ambient noise conditions. Therefore it is not considered to pose any risk of physiological hazard or behavioural effects to either whales or turtles unless they hover above the animal for an extended period of time.

The amount of behavioural effect that may arise is not considered likely to cause significant effect at the population level, as defined by the EPBC Act Matters of National Environmental Significance: Significance Guidelines 1.1 (DSEWPaC, 2009).

Summary of Control Measures

Compliance with Woodside Marine Charterers Instructions, specifically:

- Interactions between support vessels and cetaceans will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.05) Interacting with cetaceans:
    - Support vessels will not travel greater than 6 knots within 300 m of a cetacean (caution zone) and minimise noise.
    - Support vessels will not approach closer to the cetacean than 50 m for a dolphin and/or 100 m for a whale (with the exception of bow riding).
    - If the cetacean shows signs of being disturbed, support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.
- Interactions between support vessels and Whale Sharks will be consistent with the Whale Shark Code of Conduct (DEC, 2012):
    - Support vessels will not travel greater than 8 knots within 250 m of a Whale Shark (exclusive contact zone) and not allow the vessel to approach closer than 30 m of a Whale Shark.
- Interactions between helicopters and cetaceans will be consistent with EPBC Regulations 2000 – Part 8 Division 8.3 (Regulation 8.07) Interacting with cetaceans:
    - Helicopters shall not operate lower than 1,650 feet or within the horizontal radius of 500 m of a cetacean known to be present in the area, except for take-off and landing.

A- 3 Physical Presence: Physical Presence of North Rankin Complex and Support Vessels

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Location • Operational Area • Facility Layout and Description • Support Vessel Operations • Subsea Inspection, Maintenance and Repair Activities • Production and Major Projects.						X		X		F	1	Low

Description of Source of Risk

The NRC, subsea infrastructure and associated support vessels have a physical presence. There are four main areas of environmental risk associated with their physical presence, these are:

- Exclusion of other users from the area
- Potential for vessels to collide with the facilities or other vessels supporting the facility, or to snag equipment on subsea infrastructure (risks associated with this have potential for spill events and are discussed below)
- Potential collision between support vessels and marine fauna during transit
- The presence of permanent facilities provides artificial habitat for colonisation by marine organisms. Key areas include the jackets, risers and subsea infrastructure.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Protected Species	**Collisions with Marine Fauna** The NRC facility receives regular visits by support vessels, at least twice per week, to supply stores, water and diesel as required. The vessels supporting the facility may vary depending on vessel schedules and availability. All large air-breathing marine fauna species are vulnerable to vessel collision (Hazel et al, 2007; Silber et al, 2010) due to their extended surface times. Vessel collisions have been known to contribute to the mortality of marine fauna, and specifically turtles (Hazel and Gyuris, 2006; Hazel et al, 2007) and whales (Laist et al, 2001; Jensen and Silber, 2003). For both whales and turtles, the risk of lethal collision is a function of abundance of animals in the area of operations, the probability of a collision actually occurring and the probability of that collision being fatal. Further details are provided below. Whales: The humpback whale monitoring study undertaken by RPS in 2010 and baseline survey undertaken by the Centre of Whale Research in 2001 to 2004 confirmed that sightings of humpback whales on their annual migration were predominantly within the 200 m isobaths. The migratory route the whales follow between the Dampier Archipelago and Montebello Islands is a relatively narrow track inshore of the NRC Operational Area. Support vessels will traverse the migration route of humpback whales when travelling to and from the mainland, and may encounter migrating humpback whales. Other whale species known to frequent the area are expected in low

numbers only.

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 (Laist et al, 2001, Jensen and Silber 2003). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. Support vessels in transit on the open ocean are likely to be travelling between 10 and 15 knots. It can be estimated that the chance of the outcome of vessel-whale collision being lethal at this speed is approximately 60% using the logistic regression of Vanderlaan and Taggart (2007). Support vessels within a few kilometres of the NRC facility are likely to be travelling at about 4 knots. Hence the chance of a vessel/whale collision resulting in a lethal outcome within these waters is significantly reduced. 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, 2003) there are only two known instances of collisions when the vessel was travelling at less than 6 knots. Both of these were from whale watching vessels that were deliberately situated amongst whales.

Turtles: There is no available data on factors affecting the likelihood of a vessel-turtle collision being lethal. It is reasonable to assume that the higher the speed of collision the greater the risk of mortality. Studies have shown that turtles are less likely to flee from a fast moving vessel, presumably because of poor hearing and visual senses, than from a slow moving vessel (Hazel et al, 2007).

The predicted level of risk to whales or turtles is considered to be low and acceptable because of the combination of the following factors:

- the low speed of support vessels (max of 4 knots/hr) within the Operational Area (500 m), which results in a low risk of collision
- the low frequency of support vessel visits (twice per week)
- low risk of mortality to individual whale or turtle from collision at low speeds.

In the event of a whale or turtle mortality, the effect is not likely to be significant (as defined by the EPBC Act Matters of National Environmental Significance: Significance Guidelines 1.1, (SEWPAC 2009) at the population level.

Whale Sharks: vessel strikes have been identified as a potential threat to whale sharks, which may occur within the Operational Area (ie a foraging BIA overlaps the Operational Area). Unlike air-breathing fauna such as turtles and whales, whale sharks do not surface to breath. Tagging studies indicate that whale sharks spend the majority of time in water >15 m depth (Brunnschweiler et al. 2009, Graham et al. 2006, Wilson et al. 2006). Support vessels are typically present in the Operational Area twice per week. As such, interactions between vessels and whale sharks are considered to be unlikely. In the unlikely event of a collision between a support vessel and a whale shark, the relatively low speed (<4 knots) is expected to result in injury rather than mortality. Note that whale sharks in Australian waters have been shown to have fewer collision-related scars than other whale shark aggregations around the world (Speed et al. 2008).

Artificial Habitat

The presence of subsea structures including the NRC and exposed subsea flowlines has the potential to provide artificial habitats through the following mechanisms:

- Subsea infrastructure provides a hard substrate for the settlement of marine organisms that would otherwise be unsuccessful in colonising the area;
- Subsea infrastructure provide artificial habitat for marine organisms, particularly fish; and
- Exposed surface structures can be used for resting by birds.

Further colonisation of the structures over time by other species leads to the development of a fouling community, similar to that which is found on subsea shipwrecks. The presence of the structures, and the fouling community, also provides for predator or prey refuges and visual clues for aggregation (Galloway *et al*, 1981).

The environmental impacts associated with the provision of artificial habitat are locally increased biological productivity and diversity. The provision of artificial habitat on the seabed is likely to influence the composition of the benthic community in the immediate vicinity due to altered predator-grazing pressures (Hixon and Beets, 1993)

The provision of artificial habitat will have either no adverse environmental impact or a low level of

	positive environmental impact (with increased species diversity, richness and populations in the area).
Socio-economic	**Exclusion of Other Users** The presence of infrastructure has the potential to disrupt commercial users of the NRC Operational Area, including shipping and fishing. Potential impacts to commercial activities include: • navigational hazards associated with infrastructure and support vessel movements • exclusion of commercial fishing operators from the immediate area surrounding the offshore infrastructure • disruption of commercial fishing operations due to vessel transits and pipeline presence, if required (i.e. disruption of trawling operations). Shipping: The NRC has been operational since 1984 and is marked on nautical charts, surrounded by a 500 m safety exclusion zone. A cautionary zone of 2.5 nautical miles (4.6 km) applies around the facility. The NRC is not located within any major shipping lanes. AMSA has introduced a network of Shipping fairways on the NWS, the purpose of which is to direct shipping into prescribed routes which are clear of existing and planned off-shore installations. These fairways will be identical to the existing Dampier Shipping Fairway introduced in 2007. Use of the fairways is not mandatory. New editions of the relevant charts were published by the AHO in September 2012. The nearest fairways pass approximately 30 nautical miles to the west of the NRC. The actual impact of the physical presence of the NRC to shipping is the requirement for slight modifications of shipping routes to avoid the Operational Area. Potential impacts associated with risk of collisions by vessels are discussed separately. Fishing: Commercial fishing can occur in the vicinity of the NRC Operational Area. Activity in the region is associated with the State-regulated North Coast Scalefish Fishery and WA Mackerel fishery. The NRC facility itself is situated within the closed to fishing designated management unit of the NCDSF. Some of the flowline and the trunkline also traverses zones designated for trawl and trap fishing. The NRC Operational Area overlaps the Pilbara Coast Management unit (Area 2) of the WA Mackerel Fishery. The area of exclusion at the NRC facility is not expected to impact NCDSF as waters are closed to fishing. For the WA Mackerel fishery, the area of exclusion represents a very small area of available trawling grounds. Commonwealth-managed fishing is unlikely to be significantly affected by the presence of the NRC and associated infrastructure. Although the NRC Operational Area overlaps the Western Tuna and Billfish Fishery (WTBF) Management Area, the Southern Bluefin Tuna Fishery Management Area and the Skipjack Tuna fishery area, very little or no activity associated with these fisheries is expected to occur nearby to the Operational Area. The NRC Operational Area does not overlap the North West Slope Fishery Management Area.

Summary of Control Measures

- Compliance with OPGGS Act, Section 280:
  - A 500 m safety exclusion zone to be maintained around the NRC at all times.
- Compliance with the NR Complex P34 Collision Prevention Systems:
  - Systems and equipment will detect and alert facility personnel of a potential collision with the facility and respond to a potential collision with the facility
- Stakeholder Fact Sheet for the NRC distributed to relevant stakeholders as part of the 5 yearly EP reviews. Stakeholder feedback accepted and assessed following submission of this EP and throughout the duration of the approved NRC Operations EP
- Simultaneous Operations (SIMOPS) matrix is produced for the NRC:
  - Annually for IMR activities from the Nor Australis support vessel
  - On a project specific basis for all other contracted support vessels
- Compliance with Woodside Marine Charterers Instructions, specifically:
  - Interactions between support vessels and cetaceans will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.05) Interacting with cetaceans (modified to include turtles):
    - Support vessels will not travel greater than 6 knots within 300 m of a cetacean or turtle

(caution zone) and minimise noise.

    - Support vessels will not approach closer to the cetacean than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of bow riding).
    - If the cetacean shows signs of being disturbed, support vessels will immediately withdraw from the caution zone at a constant speed of less than 6 knots.

- Interactions between support vessels and Whale Sharks will be consistent with the Whale Shark Code of Conduct (DEC 2012):
  - Support vessels will not travel greater than 8 knots within 250 m of a Whale Shark (exclusive contact zone) and not allow the vessel to approach closer than 30m of a Whale Shark.

A- 4 Physical Presence: Physical Footprint

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Location • Operational Area • Subsea Infrastructure • Production and Major Projects.					X					E	1	Low

Description of Source of Risk
The environmental risk is disturbance to the seabed displacing benthic biota. During routine operations there will be little or no seabed disturbance. Some minor disturbance may result from subsea IMR activities (including the removal and installation of risers and associated dropped object protection devices), the possibility of vessel anchoring and accidental disturbance (e.g. dropped objects).

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Other Habitats & Communities	Activities which disturb the seabed can cause localised impacts including mortality/disturbance of benthos. The NRC Operational Area is located in deep open ocean waters away from sensitive benthic habitats and there is only a small area of direct seabed disturbance from the mooring, subsea infrastructure and subsea IMR activities. The removal of and installation of risers onto the seabed may result in minor, temporary, highly localised elevations in Total Suspended Solids (TSS) in the water column. The impact of disturbance is considered to be insignificant due to the very small area of disturbance to soft sediment seabed, whether considered in total or as a proportion of similar habitat available and the widespread distribution of potentially affected benthic species.

Summary of Control Measures

- Anchoring in the NRC exclusion zone will be prohibited except in emergency situations or under issuing of a specific permit.
- Compliance with the NRC SCE Performance Standard – Certified Lifting Equipment (P20):
  - Lifting and lifted equipment will be in a safe and serviceable condition to prevent dropped objects.
- Compliance with the NRC SCE Performance Standard – Cranes (P15):
  - Lifting operations will be safely performed to minimise potential for dropped objects.
- Compliance with Lifting Equipment Standard and Lifting Operating Procedures. Specifically:
  - A lift plan, specific to the operation, will be developed by a trained and competent person; and
  - Operators of powered lifting equipment will be trained and competent for that specific equipment and location.

A- 5 Routine Atmospheric Emissions: Gas Flaring During Operations

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Flare Systems			X							F	2	Low

Description of Source of Risk

Flaring of gas increases the volumes of greenhouse gases emitted to the atmosphere. Flaring will also consume natural gas, a non-renewable resource. Incomplete combustion under certain scenarios may also generate other air pollutants and dark smoke. Flaring may also reduce the visual amenity of an area via visibility from nearshore areas.

The release of hydrocarbon gas to atmosphere by flaring is an essential practice on an operating oil or gas facility, primarily for safety reasons. NRA and NRB have independent flare systems.

Operational flaring on the NRC is comprised of two elements: normal operational flaring associated with purge and pilot to maintain the flare system; and non-routine flaring that may result from equipment failure, shutdowns, production restarts, subsea flowline depressurisation and well remediation activities. During flaring the burnt gas generates mainly water vapour and CO_2. The combustion efficiency of the NRC (NRA and NRB) flare systems are estimated to be approximately 98%.

The volume of gas flared on the NRC in 2015 was 20,860 tonnes. During operations at the NRC from 2016 to 2019, it is estimated that between 19,817 and 25,692 tonnes of gas will be flared per year. The installation of NRB has increased the capacity of facility to up to 66 kt/d and there has been limited operating data since NRB start-up, hence there is some uncertainty in predicted future flaring volumes.

Flaring volumes will vary as a result of production rates, non-routine activities, process upsets and shut-downs. The forecast annual atmospheric emissions from flaring have been estimated using the E&P Forum (1994) Tier 3 (tonnes of throughput) technique (footnote in **Table 12-1**). This method is considered sufficient because any inaccuracies inherent in the method are minor in comparison to variability in forecasts of production over a five year period. The approximate annual emissions as a result of flaring are presented in **Table 12-1**. The flaring volume estimate in **Table 12-1** is based on the average annual estimated flaring volume from 2016 to 2019.

Table 12-1: Estimated Annual Atmospheric Emissions from Flaring at the NRC

Component	Flaring (tonnes) (average over 4 years)
Flared Volume	20.746
CO_2	54,147
CH_4	726
N_2O	2
CO_2eq	69,916
NOx	31
SOx	0
CO	180

Assumptions: Gas density 0.737; Flare efficiency 98%; Conversion factors after E&P Forum (1994), Tables 4.10, 4.11 and 4.15; Global Warming Potential after UNFCCC, 100 year horizon.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Air Quality	It is important to note that the flaring of gas is necessary for safe operations and therefore is in itself a mechanism to avoid potential environmental impacts. This avoidance measure is not without impact; however the environmental risks associated with flaring are much lower than the safety and environmental risks associated with not having a safe way to dispose of surplus gas at

	the NRC. Atmospheric emissions from flaring will result in a minor, localised, temporary reduction in air quality and contribute to global greenhouse gas emissions. The impact of atmospheric emissions from flaring from NRC on the surrounding marine environment of the region is insignificant. **Visual Impact** The impact of artificial lighting is discussed in a separate risk assessment. Given the NRC facility is located approximately 110 km from the Montebello Islands and approximately 135 km from the nearest mainland residences at Dampier, flare flame and smoke emissions would not be visible at these distances. As a result, the visual impact of operation of the NRC facility is assessed as insignificant.

Summary of Control Measures

- Compliance with the PSAP - NR Complex P31 Environmental Emissions Monitoring and Controls:
  - Flared gas will be combusted in an efficient manner;
  - Gas flared will be monitored at all times.
- Compliance with Performance Standard P25 Purge Gas and Blanketing System to ensure the system is operated within the design specifications.
- Compliance with Environmental Performance Operating Standard:
  - Flaring must be controlled by each facility in line with annual limits set in the operating plan and performance agreements.
  - Where a Deviation from this annual limit cannot be reasonably avoided, a business case shall be prepared and approved by Vice President Environment.

A- 6 Routine Atmospheric Emissions: Emissions from Fuel Combustion

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Power Generation • Diesel Bunkering and Usage • Support Vessel Operations.			X							F	1	Low

Description of Source of Risk

The combustion of fuel (natural gas and diesel) to power the NRC topsides and utility equipment result in emissions to the atmosphere of NO_x, SO_x, CO_2, CO and particulates. Support vessels will emit similar air pollutants from engine stacks as a result of diesel consumption.

Fuel gas consumption for power generation is the largest source of fuel combustion emissions from the Complex. In 2013, 51,511 tonnes of fuel gas were used on the NRC, the combustion of which equated to the emission of 145,623 tonnes of CO_2 equivalents. Diesel usage on the facility (excluding support vessels) in 2013 was 8,271 tonnes, the combustion of which equated to the emission of 27,046 tonnes of CO_2 equivalents.

The installation of NRB has increased the capacity of facility to up to 66 kt/d and involved the installation of an additional three gas compression turbines and supporting infrastructure, which are required to maintain low pressure production. Therefore, historic fuel gas consumption rates will not be representative of future performance.

The forecast annual air emissions from fuel combustion on the NRC have been estimated based on an average future forecast fuel gas and diesel consumption rates and are presented in **Table 12-2**.

Emissions factors are calculated in accordance with the National Greenhouse and Energy Reporting Measurement Determination. Other emissions have been estimated in accordance with the National Pollutant Inventory reporting requirements.

Table 12-2: Estimated Annual Emissions from Diesel Combustion from the NRC

Source	Fuel gas(t)	Marine Diesel (t)	Total
Fuel use	51,511	8,271	59,783
CO_2	141,657	26,468	168,125
CH_4	22	1	22
N_2O	11	2	13
CO_2eq	145,623	27,046	172,669
NOx	346	79	424
SOx	1	66	67
CO	139	17	156

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Air Quality	Inefficient operation of fuel combustion equipment has the potential to increase the volumes of greenhouse gases emitted to the atmosphere and consumption of a non-renewable natural resource. However, both support vessels and the NRC represent small sources of emissions, which are coupled with a large and relatively clear air shed and significant distance from sensitive receptors means that the impact of emissions from fuel combustion on the local environment is negligible.

	It is mandatory for all diesel sold in Australia to contain less than 500 ppm sulphur. This product is known as 'Low Sulphur Diesel'.

Summary of Control Measures

- Compliance with PSAP - NR Complex P31 Environmental Emissions Monitoring and Controls:
  - Fuel gas and diesel consumption will be monitored at all times.
- Compliance with PSAP - NR Complex P31 Environmental Emissions Monitoring and Controls and Performance Standard P25 Purge Gas and Blanketing System to ensure the system is operated within design specifications.
- Compliance with Woodside Environmental Performance Operating Standard:
  - Low sulphur fuel will be used for vehicles and stationary, subject to engine compatibility (based on engine manufacturer specifications), whenever available.
  - The sulphur content of fuel oil used by marine vessels shall meet a maximum sulphur content of 4.5% mass/mass of 1.5% m/m if the vessel is required to do so by regulation.
- Compliance with MARPOL 73/78 Annex VI (Prevention of Air Pollution from Ships) requirements as defined in the Marine Order 97 (Marine Pollution Prevention, Air Pollution) (pursuant to the Commonwealth Navigation Act 1912):
  - A valid IAPP Certificate
  - Use of low sulphur diesel when it is available.

A- 7 Routine Atmospheric Emissions: Fugitive Emissions

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are the Process Description, including: • Flare Systems • Power Generation • HVAC Systems			X							F	1	Low

Description of Source of Risk
Fugitive emissions are non-intentional releases of hydrocarbon gas. They can be caused by unintentional equipment leaks from valves, flanges, pump seals, compressor seals, relief valves, sampling connections, process drains, open-ended lines, casings, tanks and other 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 production throughput. The Department of Energy and Environment (formerly the Department of Climate Change) have released technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia, including from fugitive emissions. Using these estimation techniques, the NRC reported 1,093 tonnes of gas lost through fugitive emissions in 2013, which included 765 tonnes of methane and 330 tonnes of non-methane VOCs. This equates to 16,107 tonnes of CO2 equivalents.

Potential Environmental Impacts

Value	**Description of Potential Environmental Impact**
Air Quality	Fugitive atmospheric emissions have the potential to increase the volumes of greenhouse gasses emitted to atmosphere and result in the loss of non-renewable natural resources. Given the distance from shore and other sensitive receptors, and lack of contributing emission sources offshore, the residual risk of accidental emissions on air quality is considered low.

Summary of Control Measures

- Routine monitoring of the process plant will be undertaken by operators to identify, isolate and repair leaks.
- Systems will be hydrotested and leak tested prior to the introduction of hydrocarbons, such that systems are proved for leak tightness prior to commissioning or re-commissioning.
- Compliance with Woodside Environmental Performance Operating Standard:
  - Fugitive emissions shall be estimated and reported annually for each facility.

A- 8 Routine Discharges: Discharge of Hydrocarbons and Chemicals during Subsea Operations and Activities

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Subsea Infrastructure • Subsea Inspection, Maintenance and Repair Activities • Production and Major Projects.	X									F	1	Low

Description of Source of Risk

Hydrocarbons and chemicals may be discharged intermittently and for short durations as a result of planned routine (e.g. discharge of subsea control fluid) and non-routine (e.g. acid cleaning) operations and activities, and may include:

- Discharge of residual hydrocarbons remaining in subsea lines and equipment as a result of subsea intervention works
- Discharge of chemicals remaining in subsea lines and equipment or the use and discharge of chemicals for subsea IMR and Persephone pre-commissioning activities
- Discharge of subsea control fluids – subsea control fluid is used to control well-head and subsurface valves remotely from the facility. It is an open-loop control system, with very small amounts of control fluid discharged from the subsea control module (SCM) on the seabed when they are operated.

Potential Environmental Impacts

Value	**Description of Potential Environmental Impact**
Water Quality	There is potential for localised water column pollution and adverse effects to marine biota as a result of hydrocarbon and chemical discharges. However, planned discharges of hydrocarbons are minor and are minimised as far as practicable via flushing of the lines back to the facility. Chemical use and discharge is minimised as far as practicable for required work. **Planned Routine Discharges** The facility uses HW525 in umbilicals and the Sub Surface Safety Valve (SSSV). HW525 is OCNS A rated, however, the system it is used in is a closed loop system and therefore the product is not discharged to the environment as part of planned activities. This product is therefore is considered an acceptable product as per Woodside's chemical selection procedures. The subsea control fluid that will be used in Persephone subsea system will be Oceanic HW443, which is classed as a Group D product by the OCNS and therefore is considered an acceptable product as per Woodside's chemical selection procedures. The planned routine discharge of HW443 will occur when a valve is actuated and therefore occurs for short periods of time and in small volumes. Upon discharge the fluid is expected to rapidly dilute given the nature of the receiving environment (i.e. deep open ocean, high energy environment). **Planned Non Routine Discharges** The release of minor quantities of oil or gas to the subsea environment during planned non-routine IMR activities may result in localised reduction in water quality and may affect biota in the immediate area of the release. Due to the water depth, oil and gas will usually not bubble to the surface but will disperse into the water column which may result in slight biological oxygen demand. Due to rapid dilution the concentration of hydrocarbons and oxygen demand is expected to be below that which will affect marine organisms within a short distance of the release. Subsea IMR activities may also require the use and discharge of chemicals to ensure the integrity

	of the equipment. Chemicals discharged into the marine environment may result in localised reduction in water quality with the potential to affect biota in the vicinity of the release. However, discharges associated with subsea IMR activities are assessed and occur over short durations and will be rapidly diluted to low concentrations that are unlikely to result in toxic effects in marine biota.

Summary of Control Measures

- Compliance with Woodside's Environment Procedure: Offshore Chemical Selection and Assessment (Woodside Doc. A1000PH9105410), for the selection of operation chemicals (process and non-process) which includes:
  - Where chemicals are rated Gold, Silver, E or D on OCNS with no substitution warnings, they may be approved for use, providing they are used as detailed in the relevant contractor procedure.
  - Chemicals with OCNS rating other than Gold, Silver, E or D or those which have a substitution or product warning require an ALARP demonstration before use. The ALARP demonstration will include:
    - Details of the chemical application (volumes, concentration, location)
    - Ecotox data
    - Fate of the chemical
    - alternatives available to the Global and Australian market
- Compliance with Woodside's Chemical Management Procedure for the selection of maintenance chemicals.
- Subsea IMR activities adhere to procedures for use of acid to remove marine growth which specify maximum allowable acid concentration of 20%.
- Subsea control fluid use will be monitored and recorded and any discrepancies will be investigated to identify unplanned use and possible integrity issues.
- During subsea activities, any operational chemical use and discharge from the support vessel will be recorded.

A- 9 Routine Discharges: Discharge of Produced Water

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • PW	X	X								F	3	Medium

Description of Source of Risk
When hydrocarbons are recovered from the reservoir water may also be produced. Separation of water from reservoir fluids is not 100% effective and the 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 and residual process chemicals. Produced Water (PW) can consist of produced formation water (PFW) (a water reservoir below the hydrocarbon formation), condensed water (water vapour present within gas/condensate which condenses when brought to the surface), or a combination of both.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality and Marine Sediment Quality	Woodside's Environmental Performance Operating Standard states that, in relation to marine discharges "No effect concentration is to be achieved 95% of the time at 200 m from an offshore source". The Standard allows for an alternative reduced ecological protection (REP) zone to be established in consultation with the Regulator (i.e. through an accepted EP). This standard has been adopted following extensive field monitoring and modelling activities undertaken as part of the cumulative environmental impact assessment study of PW discharges from Woodside's NWS facilities (SKM, 2007). The approach of establishing ecological protection zones is aligned with National guidelines for monitoring and reporting (ANZECC/ARMCANZ, 2000a and b) as well as the current Environmental Quality Management Framework (EQMF) for Pilbara Coastal Waters (DoE, 2006), as per the State's implementation framework for the National Water Quality Management Strategy (NWQMS) (Government of Western Australia, 2004). The Woodside Standard is equivalent to an Environmental Quality Standard (as per ANZECC ARMCANZ), of which the overarching Environmental Quality Value is 'Ecosystem Health' and the Environmental Quality Objective is to 'Maintain Ecosystem Integrity'. PW discharge on the NRC is managed in accordance with the Offshore Marine Discharges Adaptive Management Plan (OMDAMP). This plan has been developed to detail the disposal of marine discharges from Woodside's offshore facilities in accordance with regulatory requirements and Woodside's Environmental Performance Operating Standard and to ensure that discharges are managed in a way that reduces the environmental risks and impacts to ALARP. The Offshore Marine Discharges Adaptive Management Plan is in place to demonstrate that Woodside has a clearly defined process and rationale for management of routine discharges to the marine environment, including validation monitoring and modelling requirements. The plan covers: • Environmental objectives for discharges; • Likely cause-effect pathways for discharges; • State of knowledge on the impacts of discharges; • The routine and reactive monitoring program for marine discharges; and • Trigger values for re-assessment of discharge quality. **PW Studies** Woodside has been collecting long term data related to PW discharges at its offshore assets. The most significant study commenced in 2003 as part of a cumulative environmental impact assessment study of the NWS (SKM 2007), where field surveys were undertaken along with ecotoxicity analysis and assessments of plume dilution modelling and verification. Based on these

data, and the ongoing monitoring dataset generated by the marine discharges adaptive management plan, Woodside has continually increased its understanding of the environmental issues associated with PW discharge.

A series of one off studies and routine monitoring programs associated with PW discharge have been undertaken to better understand the potential impacts of PW from NRC over its years of operation. These studies include:

- Annual chemical characterisation of undiluted PW. This is part of the routine monitoring program, to understand whether significant changes are observed in the characterisation of PW discharged to the environment. This information, when coupled with data from studies of the receiving environment and representative facilities, also aids in understanding how variability in PW stream composition over time affects the overall nature and scale of impacts to the receiving environment.
- Whole effluent toxicity (WET) testing of the undiluted PW. This is part of the routine 3 yearly monitoring program and is conducted to better understand the toxicity of each facility's PW discharge and to determine the dilutions required to achieve an acceptable environmental outcome (i.e. "safe" dilution). The most recent study was completed in 2014 and previously in 2010/11, 2006 and 2003.
- Hydrodynamic and PW plume dispersion modelling. These studies are undertaken to determine the distances required for PW to adequately mix with receiving waters to achieve required acceptable "safe" dilutions (Rob Philips Consulting 2007, 2014, and 2015).
- Fluorescent dye and dye patch studies and validation with oceanographic in situ measurements of PW plume dilution. This study was undertaken at the NRA and GWA assets and provided field data to calibrate and verify far-field PW modelling (SKM 2007).
- Studies to assess sediment chemistry and evaluate the effects of PW sedimentation and accumulation near production facilities (SKM 2007).
- PW sedimentation modelling to determine settling characteristics of particulates in PW discharges (Jacobs 2015); and Water quality monitoring and sediment quality studies undertaken in 2014 and 2015 (BMT Oceanica 2015a,b) to verify predicted impacts and improve the level of confidence surrounding the potential impacts of receiving waters and sediments (from PW discharge) adjacent to four Woodside offshore production facilities (GWA, Ngujima-yin, Okha and Northern Endeavour), which are considered representative assets and suitable to inform understanding of risk, based on nature and scale, of PW discharges across Woodside’s operating assets.

PW Management – Safe Dilution Assessment

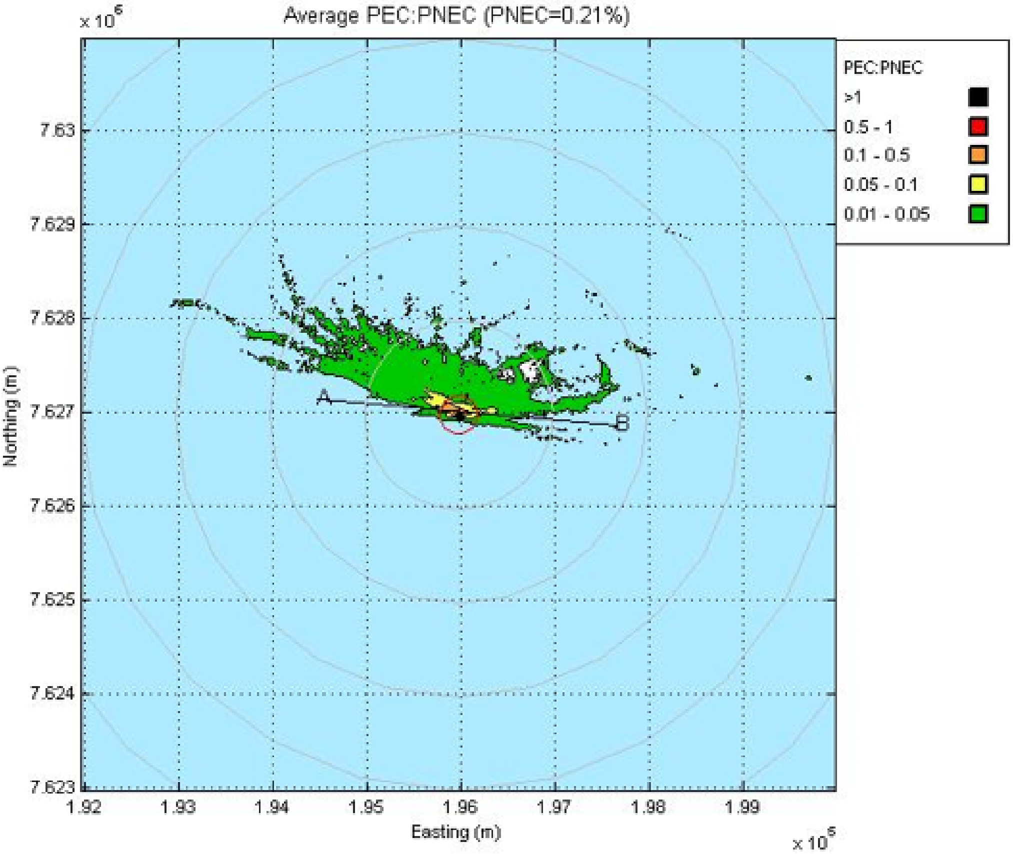
Distances from the NRC facility discharge point where predicted dilutions exceed those required for 95% and 99% species protection under different seasonal conditions are assessed with reference to a previous 3-D plume model conducted for the NRA facility (Rob Phillips Consulting, 2007). The most recent model was run under seasonal/current wind conditions for discharges equivalent to 955 m^3/day using a Predicted No Effect Concentration (PNEC) =0.21% (equivalent to 480 dilutions). **Table 12-3** provides a summary of estimated ‘safe’ dilution results for 95% (PC 95) and 99% (PC99) species protection for NRC since 2003 (Jacobs 2015 and Oceanica 2015b). These safe dilution values have consistently decreased between 2003 and 2014.

Table 12-3: Summary of estimated ‘safe’ dilutions for 95% (PC95) and 99% (PC99) species protection (Jacobs 2015 and Oceanica 2015)

Species Protection	2003	2006	2010/2011	2014
PC95	1 in 1,430	1 in 910	1 in 590	1 in 290
PC99	1 in 2,500	1 in 1,430	1 in 830	1 in 480

Figure 12-1 shows the spatial distribution of the four day average Predicted Environmental Concentration (PEC)/PNEC ratios under the worst seasonal condition (transitional, which results in least dilution) assuming a discharge rate of approximately 955 m3/day. It shows that under the worst-case conditions, the PW discharge would be diluted to safe concentrations (to meet PNEC = 0.21%) for the protection of 99% of species within 20 m of the discharge point. Assessment of the environmental hazard of PW discharge from the NRC facility for the current revision of this EP is based on scaling of these previous modelling outcomes.

The number of dilutions required was informed by the outcome of routine Whole Effluent Toxicity (WET) tests undertaken on raw and diluted PW samples. The characterisation and use of PW toxicity data in hydrodynamic modelling to ascertain the distance to achieve safe dilution levels is described below.



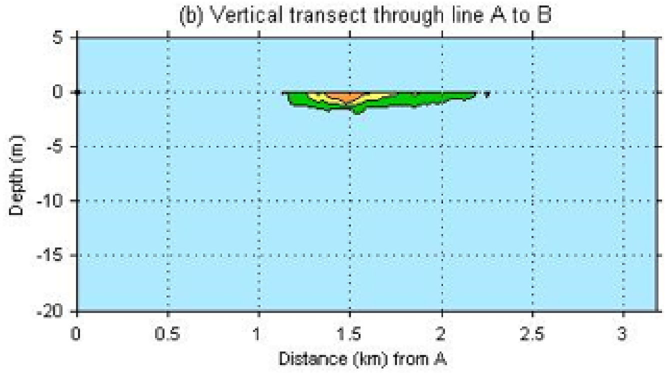


Figure 12-1: Four day average PEC/PNEC ratio for PW discharged from the NRC Facility (Transitional Season, discharge rate of 955 m^3/day, PNEC=0.21%) (Rob Phillips Consulting, 2015)

Toxicity

A detailed assessment of the potential toxicity impacts associated with the discharge of PW from Woodside's offshore facilities has been conducted periodically ('PW Discharge Management Framework' below). The results from the most recent review of toxicity of PW from the NRC facility (Jacobs, 2015) is summarised below. The method applied (Jacobs, 2015) consisted of a three step process:

- Chemical characterisation of PW;
- Assessment of toxicity and determination of the "safe" dilution for protection of 99% of species; and

- Interrogation of PW dilution modelling data to determine the boundary of environmental hazard.

Characterisation of PW

Chemical characterisation is a key element of the Offshore Marine Discharges Adaptive Management Plan (OMDAMP). It is undertaken on an annual routine basis to assess the chemical characterisation of the raw PW, or may be undertaken more frequently/at different stages based on triggers within the OMDAMP

The NRC PW discharge in 2016 had similar physio-chemical parameters to the 2014 sample (2014 is the year in which three yearly ecotoxicity was undertaken). The 2016 sample had generally lower organic chemicals and similar metals/metalloids (Jacobs 2016).

Toxicity and Safe Concentration of PW

A range of tropical Australian marine test species were selected for the direct toxicity assessment based on their ecological relevance and the availability of standard tests with known reproducibility. Test species which exhibited the most sensitive response to previous PW testing were also included to permit comparison of results with these previous studies.

The results of all acute and chronic test results were combined using ‘species sensitivity distributions’ following the ANZECC/ARMCANZ (2000) approach to obtain estimates of ‘safe’ concentrations (with 50% confidence) for protection of 95% of species and for protection of 99% of species. These “safe” concentrations are estimates of the PW concentration below which the PW would pose minimum environmental risk in “slightly - moderately disturbed” environments and in ‘pristine environments’, respectively. For the offshore marine environment surrounding the NRC facility, the 99% species protection level is applied beyond the mixing zone for assessment of potential impacts.

The calculated dilutions to meet ‘safe’ concentrations of NRC PW shown in have been determined by CSIRO Centre for Environmental Contaminants Research (Binet and Stauber, 2006; Binet et al, 2006 and Binet and Spadaro, 2011, Jacobs, 2015 and Oceanica, 2015b. These calculations are based on the respective acute EC50 data (after application of an Acute to Chronic Ratio (ACR) of 10), together with the chronic EC10 data of the sampled PW.

Environmental Hazard of PW Discharge

By combining the data on safe dilution concentration **(Table 12-3)** and previous modelling results, the aerial extent (or distance to achieve ‘safe’ dilution concentration) of the potential “environmental hazard” associated with discharging PW can be determined. Full details of the latest application of this methodology are documented in Jacobs, 2015.

The area of potential “environmental hazard” is indicated by the ratio of the Predicted Environmental Concentration (PEC) to the Predicted No Effect Concentration (PNEC) (that is: PEC/PNEC ratio). This is an established technique to screen chemicals in offshore discharges (EC, 1996) and forms the basis of the OSPAR Harmonised Notification Scheme (OSPAR, 2000).

PEC values are based on the 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 derived by Rob Phillips Consulting (Multiple references, see Jacobs 2015). If the time averaged PEC value is less than the PNEC value, then the predicted PW concentrations are less than concentrations which may potentially result in environmental harm (i.e. PW dilution is greater than the ‘safe’ dilution requirement for that PW). Conversely, if the PEC/PNEC>1 then the ‘safe’ dilution requirement for 99% species protection has not been met.

The distances to where safe dilutions were modelled for the typical discharge rates in 2014, are shown in **Table 12-4**. Modelling results indicate that under worst-case conditions, the PW from the NRC facility is diluted to safe concentrations for the protection of 99% of species within 20 metres of the facility. It can be concluded PW discharge from the NRC facility poses little environmental risk at the present discharge rates with the distance to achieve safe dilutions likely occurring within 20 metres of the discharge. Information regarding the adaptive management program in place to address changes in produced water rates and other factors which may alter these results is outlined within the ‘Produced Water Management Framework’ Section of the NRC EP.

Table 12-4 : PW Discharge Parameters and Modelled/Interpolated Distances to Achieve ‘Safe Dilutions’ based on most recent ecotoxicity and modelling data

Modelled Discharge Scenario	Dilutions Required*	Modelled discharge (m3/day)	Maximum distance at which safe dilution Modelled Discharge is achieved (PEC:PENC=1)	
			Modelled (m)	Interpolated (m)
2013 Modelled**	830	173	<20	
2013 Average**	830	480		<50
2014 Actual***	480	680	<20	
Expected NRC Maximum***	480	955	<20	
NRC with PSP***	480	1900		<50

** Dilutions required to meet 99% (PC99) species protection.*
*** Based on 2011 ecotoxicity analysis*
**** Based on 2014 ecotoxicity analysis*

Table 12-4 includes the discharge scenario of NRC with PSP. The modelled discharge rate represents the maximum water production capacity of NRC with the addition of PSP and the operation of the second centrifuge. This data shows that even at maximum water production rates the distance to achieve safe dilutions (based on current toxicity date) is within 50 m.

Based on this assessment, the PW discharge is not predicted to result in any significant toxicity effect to protected species. It is probable that PW discharge may affect the community structure of biofouling associated with the NRC facility but this will be of very minor/negligible nature. It is very unlikely that there will be any toxic effect beyond a localised mixing zone.

Summary of potential ecological impacts of produced water discharges

Fish and planktonic communities have the potential to be impacted by PW discharges. However, monocyclic aromatic hydrocarbons and polycyclic aromatic hydrocarbons that are generally regarded as the toxicants of most concern were not detected during the Routine Sediment Sampling/Analysis and Water Quality Monitoring field studies.

Coral, seagrass and macroalgae communities would be unlikely to inhabit the seabed in the vicinity of the NRC as the depth is generally beyond that required for growth and survival and sediment samples and seabed imagery of all studies undertaken in the past contained no record of seagrass, macroalgae, coral or sessile invertebrates.

Sessile invertebrates on the seabed could be impacted within the mixing zone (on the seabed) and beyond. Sessile invertebrates attached to the facilities could be exposed but are within the REP zone boundary.

From the PW studies undertaken at NRC it is unlikely that PW effects would extend outside of the current reduced ecological protection zone boundary even with the increase in discharge volumes expected when bringing PSP on line. There does appear to be elevations of metal concentrations outside 200 m in the sediment and even though this is expected to be due to legacy NWB mud drill cuttings underneath the platform with little likelihood of biological effects due to the concentrations being below ANZECC/ARMCANZ (2000) and Simpson et al (2013) ISQG –low guidelines, it is appropriate to take these elevations beyond background concentrations outside of 200 m into account when factoring in the boundary of the REP zone.

Based on the assessment above the REP zone for NRC is established as 500m. Changes to the produced water volumes and composition which could potentially increase impacts will be managed via the Offshore Discharges Adaptive Management Plan.

PW Routine Discharge Monitoring

Woodside has in place an Offshore Marine Discharges Adaptive Management Plan which outlines existing routine monitoring undertaken for PW discharge from offshore facilities including the following parameters:

- Discharge volume
- Oil in water concentration
- Chemical characterisation
- Routine verification testing (whole effluent monitoring)

- Routine sediment sampling and analysis

Marine Sediments

Accumulation 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. Assessments of the NRC facility PW composition strongly suggest that the impact of PW sediment accumulation is minimal and managed to ALARP. Information supporting this assessment is discussed below.

The concentration of Total Organic Carbon (TOC) in PW ranges from < 0.2 to more than 11,000 mg/L and is highly variable from one well to another (Neff *et al*, 2011). Burns and Codi (1999) found that 36% of the hydrocarbons discharged from “Harriet A” platform on the Northwest Shelf become attached to suspended particles, of which one third settle to the seabed within 900 m of the platform. However, the “Harriet A” discharge is unusual as it contains high levels of suspended particulates compared to many other discharges (Cohen, 2001). By comparison, measured TOC concentrations in NRC PW discharges are very low, recorded at 340 mg/L during 2011 and 110 mg/l during 2014

Further studies into potential sediment accumulation from PW discharge have recently been undertaken by Woodside, including analysis of a representative sample of PW from the GWA facility (SKM, 2013a). The sample of PW was analysed for filtered and total extractable metals, metal bioavailability, total suspended solids and particle settling analysis. Sedimentation analysis concluded that the PW had a very small amount of solid material, 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 Marine and Freshwater Research Laboratory (MAFRL) microanalysis laboratory on the sample but no results were recorded because of the low concentration and small size of the particulates. Examination of the sample under scanning electron microscope found the majority of particles to be of a size of approximately 2 to 3 µm (SKM, 2013a).

To expand further on the above study, particle size assessments have also recently been conducted for the produced water of all three of Woodside’s NWS assets (GWA, NRC and Angel; Jacobs 2016). The total suspended solids (TSS) in produced water were low for Angel (0.6 mg/L) and NRC (2.4 mg/L) and slightly higher for GWA (7.6 mg/L). The size distribution of the particles in the produced water was lowest for GWA and NRC, but the majority of particles for all assets were less than 40 um (refer **Table 12-5** below).

Table 12-5: Particle size ranges of PW from the NWS facilities

Facility	Size Range (µm)	% smaller than 5µm	% smaller than 40µm
Angel	0.4-80	11	91
GWA	0.4-20	74	100
NRC	0.22-14.2	75	100

Dr Graeme Hubbert, an oceanographer from Global Environmental Modelling Systems, categorised particulate behaviour based on oceanographic experience and mathematical calculations using settling rates and re-suspension velocities for various particle sizes (SKM, 2013a). He determined that particles of a size 1 to 5 µm would never permanently settle out of the water column and that particles of a size 5 to 40 µm would not permanently settle out of the water column unless they were in very deep water (>500 m) or in areas where hydrodynamic conditions were very weak and did not continuously resuspend the particles.

From the combination of low concentration of particulates in the produced water, their small particle size and the location of the asset in a dynamic open ocean environment, this strongly indicates that the impact of PW discharges from NRC on sediment accumulation of toxicants is minimal and managed to ALARP. This is supported by sediment analysis undertaken at NRC and other representative assets which is discussed further below.

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 NRC facility is approximately 28.25 mg/L (2011-2016 analyses). Bioaccumulation of BTEX compounds has been observed to occur in the laboratory but only at concentrations far in excess of that discharged from the NRC 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 NRC 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 produced water 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 produced water chemicals by marine invertebrates and fish around several offshore production facilities discharging more than 731 m3 per day of produced water to outer continental shelf waters of the western Gulf of Mexico (by comparison NRC discharges are currently around 480 m3/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 semivolatile 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 produced water, 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 produced water 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 produced water discharges or from tar balls or small fuel oil 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 NRC, however, there may be an elevation in PAH levels. Given the similarity of the chemical characterisation of PW discharges from the NRC and other nearby platforms to those elsewhere in the world including those in the Gulf of Mexico (SKM 2007), the results from Neff et al (2011) can be used to infer the very low likelihood of potential 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 NRC facility.

Woodside will undertake future periodic sediment monitoring surveys for a representative facility with findings to be used to review and update this risk assessment, as appropriate.

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-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 operational exclusion zones which prohibit fishing from or near the platform, and the absence of regionally important commercial fisheries in the waters surrounding the NRC.

Sediment Studies

2006 NWS Sediment Analyses

As part of the NWS cumulative environmental impact study (SKM 2007), sediment samples were collected in the vicinity of the NRA (now NRC) and GWA 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 100 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 the ANZECC/ARMCANZ SQG limit (300 mg/kg). A single sample at 100 m distance away from each of the NRA and GWA facilities recorded TPH concentrations similar to or exceeding the ANZECC/ARMCANZ SQG limit, however, subsequent analyses revealed that neither PAHs nor other organic contaminants of concern were detected.

Concentrations of metals were also low (below ANZECC/ARMCANZ Interim SQGs) or below detection limits beyond 100 m from both platforms. Mercury and lead were detected in concentrations above low level ISQG limits in samples collected 100m from the NRA facility, however recent bioavailability analyses (SKM, 2013) indicates that mercury is not soluble in seawater and therefore not in a form that is biologically available to organisms in the sediment or the water column should the sediment be disturbed or re-suspended. Likewise bioavailability testing also showed that lead was not soluble in seawater and therefore not in a form that is biologically available to organisms in the water column, however, it is available to organisms living in the sediment that may ingest it.

Barium, a non-biodegradable weighting agent used in all types of drilling muds, was detected in the sediments in decreasing down-current and cross-current gradients up to 10 km and 1.2 km distances, respectively, indicating the presence of drill cuttings in these sediments.

Sediments at the NRA facility were sampled for hydrocarbon content in 1991, 1995 and 1997 to determine the rate of degradation of hydrocarbons post the 1991 NWBM drilling campaign (Oliver and Fisher, 1999). The results of that study at NRA showed a hydrocarbon half life of approximately one year for the first three years post drilling. The hydrocarbon concentrations in the sediments surrounding NRA are expected to be weathered hydrocarbons derived from drilling activities, not PW sedimentation. Regardless of source, the hydrocarbon concentration in the sediments surrounding the NRA facility in 2006 were very low, similar to background conditions and well below sediment quality threshold values.

Based on this information, it is very unlikely there is any significant accumulation of PW derived hydrocarbons or metals in sediments surrounding the NRC facility. Direct measurements of hydrocarbons in sediments from NRA and GWA, where PW discharges have occurred since commissioning in 1984 and 1995 respectively, identified only very low levels, similar to background and well below proposed SQG values (ANZECC/ARMCANZ SQG limit). Likewise, direct measurements of mercury in sediments were below detection at all locations beyond 100 m from either facility, and non-bioavailable for two replicates collected 100 m from NRA, with other metals generally below detection limits or Interim SQG low limit values beyond 100 m.

2013 NRC Sediment Analyses Considering Bioavailability

A sediment sampling survey was conducted in 2012 at sites located to the east of NRA platform (SKM 2013). This study was not conducted for the purposes of understanding PW impacts but to evaluate and assess potential impact from the Persephone development installation activities (specifically cutting pile disturbance associated with connection of the subsea tieback to the NRC riser).

In order to assess any impacts arising from this potential disturbance, sediment samples were collected at various distances from 15 m to 216 m from the platform to better understand the nearby sediments and 2 km to determine background concentrations. Sediment samples were analysed for metals and hydrocarbons and any exceedances of the ANZECC/ARMCANZ (2000) ISQG-low trigger values were tested for bioavailability by dilute acid extraction to determine if metals would be bioavailable to organisms living within the sediment. Elutriate testing was also conducted to determine if there would be a release of metals to the water column following disturbance of the sediment.

Chemical analysis of the samples found that beyond 127 m from the platform, TPH concentrations were below detection limits, similar to concentrations in other non-impacted areas, and well below the SQG limit (300 mg/kg). Samples closer than 127 m distance from the platform recorded TPH concentrations above the SQG. No bioavailability testing of hydrocarbons was conducted at this time due to the close proximity of the higher results and being below detection beyond 127m. However, recent sediment studies conducted at GWA in 2015 identified some replicate samples above the SQG for TPH at both 100 and 200 m from the facility. However, subsequent analysis revealed that neither PAH or other organic contaminates considered to be bioavailable were detected (Oceanica 2015)

Concentrations of metals were also low (below ANZECC/ARMCANZ (2000) Interim SQGs) beyond 116 m from NRA. Mercury and lead were detected above the ISQG-low at four sites closest to the platform (the most distant of which was at 116 m). The detected exceedances at the 116 m site had a similar concentration to results for the 100 m site in 2006. Barium was detected at above background levels at the sites with metal/TPH exceedances indicating the presence of drill cuttings at the sample site sediments. Barium is a non- biodegradable weighting agent present in all types of drilling muds.

Bioavailability and elutriation testing was conducted as part of this study, and found that mercury was not bioavailable and would not be released to the water column when the sediment was disturbed. Virtually all lead was bioavailable but was unlikely to be released to the water column upon disturbance of the sediment; therefore the biological effect of lead would be confined to organisms living within the sediment. It should also be noted that lead is not detected in the NRC

PW stream, as all chemical characterisation testing of the NRC PW has lead concentrations below the CSIRO laboratory detection limits, the current sample for 2016 being 0.04 µg/L (the ANZECC/ARMANZ (2000) lead trigger value for 99% species protection in marine water is 2.2 µg/L), therefore the high concentrations of lead found in the sediments underneath the NRC facility are more likely to occur from the historic drill cuttings piles.

All metals concentrations were lower than ANZECC/ARMCANZ (2000) Interim SQGs at 127 m from the platform, however, at 216m the majority of metals were still slightly above background concentrations determined from sediment sampling at 2km. Therefore there does appear to be a slight elevation of metals beyond 200 m but they were below the ANZECC/ARMCANZ (2000) ISQG low guidelines. The ISQG-low is considered to be the threshold at which the concentration of the chemical stressor in sediment causes a biological effect (below which there would be no biological effect) (Simpson et al. 2013). Therefore the impact of metal concentrations above background concentrations beyond 200 m would not cause a biological effect.

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-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 operational exclusion zones which prohibit fishing from or near the platform

2014/15 Routine Sediment Sampling and Analysis

Routine Sediment Sampling/Analysis and Water Quality Monitoring field studies were undertaken in 2014/2015 for comparison with dilution model results and to assess the sediment quality adjacent to numerous Woodside assets; GWA (gas condensate platform), the Okha floating production, storage and offloading (FPSO) facility Ngujima-Yin (NY) FPSO and the Northern Endeavour FPSO.

The overall objectives of these studies were to provide additional field verification to support the conclusions made related to potential impacts and risks of PW discharges and to validate the acceptability of Woodside's Offshore Marine Discharges Adaptive Management Framework and/or provide additional recommendations for adaptation or improvement.

The North West Shelf component of these studies was undertaken at and around the GWA facility. GWA is a gas and condensate production facility located approximately 23km from the North Rankin Complex (NRC). GWA has been determined to be of relevance to and effective for management of PW and informing the assessment of potential accumulation of contaminants in sediments at NRC for the following reasons:

- The facilities are located within close proximity (~23km), are in similar depths of water (125-130m) and experience similar metocean and discharge mixing characteristics;
- The volume of water discharged from GWA is significantly higher than the volume of water discharged from NRC. In 2014, the rate of water discharged from GWA was approximately 400% higher than NRC. Noting this, contaminant loads discharged from GWA would be higher, with a greater potential for sediment accumulation at GWA, if a significant risk of sediment accumulation as a result of PW discharge exists.
- An analysis of total suspended solids and particle size distribution shows that any potential for sediment accumulation at NRC would be conservatively the same, but likely less than GWA due to the PW composition combined with total water discharge rates.
- GWA and NRC produce gas, condensate and water from the same or nearby reservoirs. The facilities also have similar water separation and handling systems, with no marked differences that would alter the suspended sediment concentrations of water being discharged and therefore that would present greater potential for sediment accumulation (e.g. water is not routinely treated via filtration). On this basis, results from recent sedimentation analysis of GWA PW (refer page 163 of the NRC EP) are believed to be a reliable analogue of NRC PW.
- NRC currently produces no PFW from its reservoirs and only condensed water, compared to GWA which has produced a combination of PFW and condensed water. This production profile aligns with Woodside's overall understanding of toxicity drivers within PW, being that facilities which discharge only condensed water show lower toxicity compared to those containing PFW.
- GWA is a better representative facility to understand potential changes to known impacts due to operational changes. For example the operational history of GWA includes two subsea tieback projects (Echo Yodel and Perseus over Goodwyn) and increasing water rates over time including the introduction of PFW. To date NRC has only produced from

the platform based wells and has not produced notable volumes of PFW.

- A comparison of metal concentrations from undiluted PW from NRC and GWA indicates similar composition with no indicators suggesting greater potential for sediment accumulation, particularly those with potential to bioaccumulate. Furthermore, concentrations of total organic carbon have been measured to be low in both GWA and NRC PW.
- Sediment analysis information available for both NRC and GWA are similar, with the exception of drilling derived materials, with TPH and metals only present in higher than background concentrations within close proximity to the facility.

Results from the 2014/2015 surveys indicated that toxicity to water column marine biota from Woodside PW discharges was negligible. At GWA, the modelled distances to achieve safe dilution may be highly conservative, as in situ DTA testing indicated very little toxicity at 200 m from the facility, which is significantly different to modelling results.

There were exceedances of the ANZECC/ARMCANZ (2000) interim sediment quality guidelines (ISQG) low for mercury and zinc within the 200 m of the GWA facility. The likely source of these contaminants is however believed to derive from historical drilling mud discharges from the platform drilling activities.

It is noted that there was a single exceedance of the ISQG low for zinc at the 200m (from the facility) site, which was then recorded at background concentrations at the next site at 400m from the platform. Noting the nature of the offshore environment this result is deemed insignificant given results confirmed concentrations were at background at 400m from the facility. Furthermore, when considering nature and scale of proven impacts (assessing impacts within hundreds of metres of an offshore platform) it is not practicable nor deemed warranted to assess such an exceedance at a closer spatial scale.

The survey results at GWA demonstrate that sediment concentrations of metals and other potential toxicants beyond 200 m did not exceed the ISQG-low (with the exception of minor uncertainty for Zinc, confirmed below the guideline at 400m). When considering nature and scale of impacts, and noting the exceedance of low trigger value guidelines within a very localised area of an offshore platform, impacts and risk from PW discharges on accumulation of contaminants in sediment continues to be deemed acceptable and ALARP.

Furthermore, based on the demonstration that GWA is an appropriate representative site for the assessment of potential sediment accumulation from NRC PW discharges (and likely to be a conservative comparison), impacts from NRC are also deemed ALARP and acceptable based on the nature and scale of impacts.

The findings of the Routine Sediment Sampling/Analysis and Water Quality Monitoring field studies completed at GWA validated the conclusion within Woodside's EPs 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-threatened species in waters immediately surrounding each facility".

Persephone Development

The Persephone (PSP) Development will involve the recovery of gas and condensate from the Persephone field (manifold with two wells) to the NRC. The addition of the PSP Development is expected to increase the total PW for NRC to a maximum rate of 1900m^3/d (maximum design basis). To manage additional water from the PSP Development and to maintain treatment performance an additional centrifuge is being added to the facility to upgrade the topsides water processing capacity on NRC from 955m^3/d to 1900m^3/d of PW (refer to Section 3 for additional details around the PSP Development).

The Persephone field is considered to be analogous to the current NRC fields, with PW expected to be of a similar composition to nearby reservoirs. Current treatment of PW via centrifuges on NRC is effective in reducing contaminants and is expected to continue to be effective. As the PSP PW is considered likely to be of a similar composition to the existing NRC fields PW, it is expected that the PW discharge will have a similar chemical characterisation.

Based on ecotoxicty testing conducted in 2014 480 dilutions are required to achieve the no effect concentration for NRC PW. Based on NRC's current expected maximum PW discharge rates (955 m3/day) this is achieved within 20m of the facility (**Table 12-4**). Increased water rates predicted as a result of the PSP Development (i.e. increased to approximately 1900m3/day) were interpolated against existing modelling data, ecotoxicity testing and estimated reservoir compositions and are expected to achieve safe dilutions within 50 m of the NRC (Table 12-4).

PSP Development Treatment Capacity Upgrade and Forecast of Timing and Magnitude of PW Discharge Rates

For the Persephone Development, the topsides water processing capacity on NRC is to be upgraded from 955m^3/d to 1900 m^3/d of PW. This upgrade will be achieved by the installation of an identical second centrifuge on NRA and debottlenecking topside PW pipelines from 3” to 6” to account for increased PW flow.

The PW production profile has been forecast for the PSP development. This shows a progression from initial production of condensed water only, transitioning to also include PFW as the fields mature, which increases total PW production rates. Due to uncertainty in exact timing and production rates, three potential scenarios (expected, early PFW production and late PFW production) have been established to anticipate produced water rates from the Persephone tieback. For the purpose of this assessment, the expected scenario will be used and is based on the likely reservoir parameters. Whereas, the early case scenario, consists of a relatively strong aquifer, pessimistic relative permeability and reduced fault transmissivity. The reference scenario is the profile shown in **Figure 12-2**, and includes the production of condensed water upon start-up of the PSP wells, transition to the production of PFW from the wells in July 2021. As previously discussed, until PFW is produced, contribution of PSP to PW will be of condensed water only, and consist of a low amount at ~18% of total NRC PW volumes. Furthermore, even if an earlier PFW production scenario occurs, the production profile will remain the same, with a period of condensed water production and pronounced spike showing the introduction of PFW.

Application of PSP under the Adaptive Management Plan

Under the Offshore Marine Discharges Adaptive Management Plan (OMDAMP), there are triggers and responses to consider in order to verify changes to PW will continue to achieve safe concentrations within the approved mixing zone and impacts and risks remain ALARP and acceptable.

Routine monitoring such as continuous operations and process monitoring, annual Chemical Characterisation and three yearly Eco-toxicity testing will be conducted at NRC as planned. However, the introduction of PW from PSP will also be considered in relation to the defined triggers and monitoring requirements of Woodside’s OMDAMP.

For the purposes of this assessment, the key trigger relates to the tie back of new wells and potential change in chemical characterisation and ecotoxicity (‘PW discharge rates or source water changes’ trigger). This trigger will first prompt desktop assessments of the change in risk (ie in addition to that provided for in this EP). Chemical characterisation of the produced water at key stages to include the addition of PSP will be undertaken to inform this assessment. This will be the key component of adaptive monitoring undertaken to assess potential changes in PW at identified key stages (**Figure 12-2**) and any associated potential change in risk and impacts. If the results of this assessment show a potential change in risk and impacts then further adaptive assessment as per the OMDAMP will be implemented, and may include ecotoxicity assessment in the first instance, and if warranted additional field based verification at NRC.

Figure 12-2 shows the predicted PW profiles associated with the production of PSP and at which stages the PSP specific chemical characterisation analysis will be undertaken. This figure shows that the first sampling will be done at a time which captures the addition of PSP condensed water only (Sample/Stage 1) to the current NRC stream, and will as such be compared to the most recent NRC sample without the addition of PSP. Another sample trigger will also occur when PFW is being produced by PSP (Sample/Stage 2). This sample will be compared to the previous sample of NRC PW and the combined NRC and PSP condensed water sample. These sampling events cover the two key periods which may alter the current known composition and as such overall toxicity and potential impacts of the discharge.

The estimates of PFW production are based on expected reservoir estimates. PFW may be produced earlier or later, however it’s important to note that the produced water production profile (i.e. the peak in water rates and the duration of production) are predicted to be the same. The only variability is the time at which production of PFW will occur. Condensed water rates will not vary in any notable way, as they are dependent on hydrocarbon production rates and are not reservoir driven. Therefore the proposed adaptive sampling will be based on the appropriate time where the introduction of PSP produced water is triggered, and not the specific date(s) as shown in the estimate in Figure 12-2.

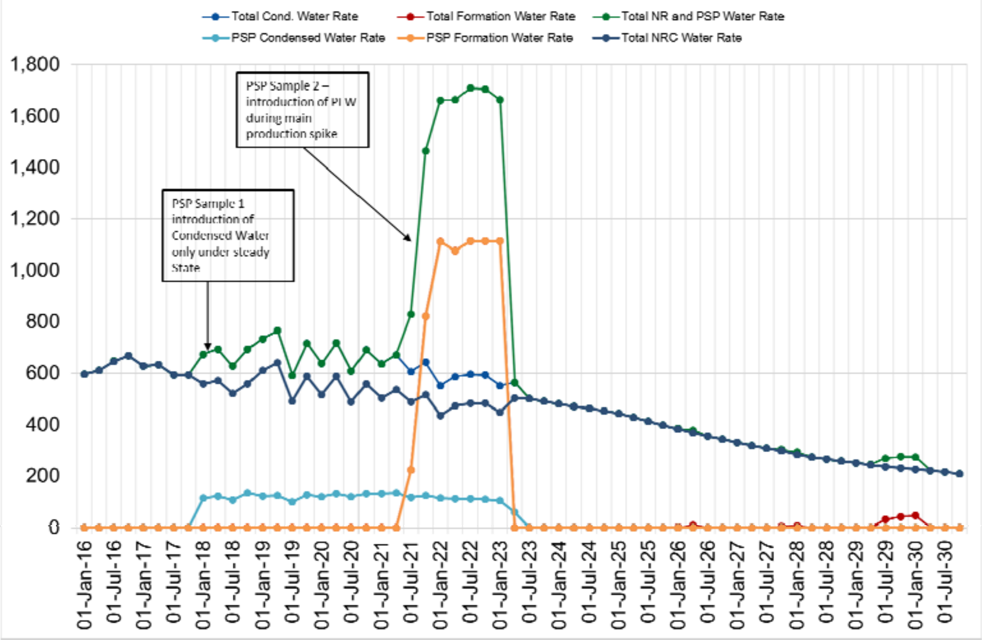


Figure 12-2: Predicted PW production from NRC including the introduction of PSP (m3 per year) showing relevant triggers to assess chemical characterisation of the PW stream with the addition of PSP.

Environmental Risk Associated with the discharge of PW from the Operation of PSP Wells

An examination of environmental risks associated with the discharge of additional PW as a result of the PSP Wells has been considered throughout this section. An increase in overall PW volume overboard from 955 m^3/day to 1900 m^3/day future maximum is predicted to increase the zone until "safe dilutions" is reached from <20 m to approximately 50 m, which still remains within the currently accepted mixing zone. This distance is still deemed acceptable based on the dimensions of offshore facilities, the locations of the discharges and the absence of nearby sensitive receptors. Furthermore, the distance is comparable to mixing zones established for onshore

Summary of Control Measures

- Application of the ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality: The contaminant should be reduced to a 'no effect concentration' outside of a mixing zone.
- High level pre-alarms are provided on the degasser water compartment to protect against overflow.
- Separation equipment is designed and maintained to achieve final OIW concentration of less than 30 mg/L.
- PW discharges overboard are monitored by a continuous online analyser.
- The concentration of petroleum in any produced formation water discharged into the sea as a result of the operation of NRC will not exceed than an average of 30 mg/L over any daily (24 hour) period.
- The produced water centrifuges will be maintained to minimise unplanned outages and ensure efficient produced water treatment performance.
- The water condensate interface in the Drain Sump Caisson will be managed to prevent underflow of hydrocarbons by maintaining the hydrocarbon interface above the high alarm operating limit of 21m below the low water reference point.
- Compliance with PSAP - NR Complex P31 Environmental Emissions Monitoring and Controls:
  - PW discharge volume and OIW concentration will be monitored and controlled;
  - Discharge of PW with high OIW concentrations will be prevented.
- Compliance with Woodside's Environmental Performance Operating Standard:
  - No effect concentration will be achieved at the following distances from the NRC asset (i.e. defined as the Reduced Ecological Protection (REP) zone);
    - 200m for 95% of the time for the water column;

        - 500m for sediments.
    - PW chemical composition and toxicity shall be characterised at/prior to commencement of operations and re-tested every 3 years or more frequently if risk is identified.
- Compliance with the Offshore Marine Discharges Adaptive Management Plan:
    - Routine monitoring of PW will be undertaken in accordance with the plan;
    - Additional verification assessment or monitoring will be undertaken should there be potential for a change to discharge characteristics, which may alter existing compliance with the performance standard;
    - further sediment sampling for toxicity at NRC will be undertaken no later than 5 years from the date of EP acceptance.

A- 10 Routine Discharges: Discharge of Sewage and Putrescible Wastes

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Sewage and Putrescible Wastes	X									F	1	Low

Description of Source of Risk

Sewage produced on the NRC is treated prior to discharge overboard. Separate systems are provided on NRA and NRB. Blackwater (from toilets) is combined with greywater (from sinks, showers, washing and hand basins) is treated by maceration prior to disinfection and disposal overboard via caissons below the waterline.

The primary environmental risk associated with ocean disposal of sewage is eutrophication. Eutrophication occurs when the addition of nutrients, such as nutrients and phosphates, causes adverse changes to the ecosystem, such as oxygen depletion and phytoplanktonic blooms.

Disposal of treated sewage effluent and putrescible wastes will result in some nutrient inputs to the marine environment which will be rapidly taken up by and stimulate phytoplankton growth. Small nutrient additions have the potential to have a minor biostimulatory effect on phytoplankton growth in receiving waters, with nitrogen availability being primarily responsible for mediating phytoplankton growth (i.e. the limiting factor) in the marine environment. In contrast, the potential for eutrophic conditions to form due to anthropogenic inputs would require the occurrence of high nutrient loading and conditions where nutrients accumulate due to inadequate flushing/dispersion. Under such circumstances, nutrient additions leading to formation of eutrophic conditions can give rise to adverse changes to an ecosystem due to, for example, harmful algal blooms and associated oxygen depletion.

The volume of sewage and grey-water generated is conservatively estimated to be in the order of 24 to 25 m3 per day when the facility is manned (based on an average volume of 75 L/person/day and maximum overnight POB capacity of 330) (Minerals Management Service, 2000). The loading of total nitrogen (TN) and total phosphorus (TP) from sewage discharge is estimated (based on an average concentration in discharge of 5 to 10 ppm TP and 40 to 100ppm TN) (Washington State Department of Health, 2005) to be:

- TN Load: 0.96 to 2.5 kg/day; and
- TP Load: 0.12 to 0.25 kg/day.

Food waste, a putrescible waste, is also a source of nutrient enrichment and is addressed in this section for the purpose of addressing cumulative effect. Studies on food waste on ships (Polglaze, 2003) have indicated average dry weight nutrient content of 2.4% TN and 0.4% TP. The total TN and TP loading from food waste discharge (assumes 1 L/day per person of food scraps and manning level of 330 resulting in approximately 202 kg dry weight) is estimated to be:

- TN Load: 4.85 kg/day; and
- TP Load: 0.81 kg/day.

The cumulative nutrient load from sewage, grey-water and food waste is estimated to be:

- TN Load: 5.81 to 7.35 kg/day; and
- TP Load: 0.93 to 1.06 kg/day.

Support Vessels

Sewage and grey-water onboard each of the support vessels are treated onboard by a MARPOL Certified Sewage Treatment Plant (STP). The STPs are maintained according to manufacturer's specifications and records of maintenance are kept in a STP maintenance book. The total nutrient load from support vessels in the field has been estimated to be:

- TN Load: 0.22 to 0.27 kg/day; and
- TP Load: 0.03 to 0.04 kg/day.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality	Although the NWS is characterised as a low nutrient environment (DEWHA, 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 (6.03 to 7.62 kg/day of TN and 0.96 to 1.10 kg of TP/day) is inconsequential in comparison to the daily turnover of nutrients in the area. The impact of nutrients associated with discharge of sewage, grey-water and putrescible waste is considered to be insignificant because of the small mass relative to daily turnover, the treatment of black water through a MARPOL certified STP, and the assimilative capacity of the receiving offshore environment. Therefore, the environmental impact associated with the discharge of sewage and putrescible waste is considered to be acceptable.

Summary of Control Measures

- Compliance with Waste Management Plan for Offshore Facilities (Woodside Doc. W8000AH001):
    - Sewage from the facility will be macerated prior to discharge to sea; and
    - Putrescibles wastes will be macerated to < 25 mm particle size prior to discharge to sea or sent to shore for disposal.
- For support vessels, compliance with MARPOL 73/78 Annex IV: Sewage (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983); Marine Orders - Part 96: Marine Pollution Prevention – Sewage:
    - Vessel will hold current International Sewage Pollution Prevention (ISPP) Certificate;
    - Sewage treatment system will be certified under MARPOL MEPC.2 (IV) or MEPC.159 (55);
    - Discharge of sewage which is not comminuted or disinfected will only occur at a distance of more than 12 nautical miles (nm) from the nearest land;
    - Discharge of sewage which is comminuted or disinfected using a certified approved STP will only occur at a distance of more than 3 nm from the nearest land;
    - Discharge of sewage will occur at a moderate rate while vessel is proceeding (> 4 knots), with no visible floating solids or discolouration of the surrounding water.

A- 11 Routine Discharges: Discharge of Cooling Water

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Water Systems.	X									F	2	Low

Description of Source of Risk
Cooling Water The environmental risk is: • Discharge of cooling water causing localised elevation in ambient seawater temperature leading to adverse physiological effect to biota in the water column • Residual sodium hypochlorite (used as biocide) in cooling water causing toxic effect to biota in the water column • Residual chemicals in tempered water systems causing toxic effect to biota in the water column. The electro-chlorination system utilises chlorine in an electrochlorination unit to generate sodium hypochlorite via the electrolysis of seawater. The sodium hypochlorite is dosed at the seawater intake point as a means to prevent fouling growth within the cooling system pipework. In seawater, hypochlorite undergoes hydrolysis to yield hypochlorous acid, which is a weak acid. An electrochlorination unit generates a concentrated sodium hypochlorite solution for injection into the circulation system, at a target chlorine level of 0.5 ppm.

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Water Quality	**Elevation in Temperature** Elevated seawater temperatures are known to cause alteration of the physiological processes (especially enzyme-mediated processes) of exposed biota (Wolanski, 1994). These alterations may cause a variety of effects, ranging from behavioural response (including attraction and avoidance behaviour), minor stress and potential mortality for prolonged exposure. Elevated seawater temperatures are known to cause alteration of the physiological processes (especially enzyme-mediated processes) of exposed biota (Wolanski, 1994). These alterations may cause a variety of effects, ranging from behavioural response (including attraction and avoidance behaviour), minor stress and potential mortality for prolonged exposure. After reviewing the ANZECC guidelines and water temperature data for the NWS, Woodside set the target in Woodside's Environmental Performance Operating Standard) as: • Temperature increase is to be less than 3°C above ambient, 95% of the time at 200 m from the offshore discharge source (i.e. defined as the 'approved mixing zone'). The seawater pumps on NRC are designed to discharge approximately 15,180 m^3/hr cooling water (equivalent to 364,320 m^3 per day). The average seawater discharge is 45°C. As described in Section 4, the surface seawater temperatures off the NWS range from about 22ºC in winter and 30°C in summer. The maximum difference between the temperature of the plume and temperature of ambient surface water is therefore about 25°C, indicating few dilutions are needed for temperature of the cooling water plume to fall to ambient temperature of the receiving waters. Upon discharge to sea, the cooling water will initially be subject to turbulent mixing and transfer of heat to the surrounding waters. The plume would then rise to the sea surface where further dilution and loss of heat would occur as the plume is dispersed in the prevailing currents. Cooling water modelling using Cornell Mixing Zone Expert System (CORMIX 6.0) to describe nearfield mixing processes of a similar discharge rate of cooling water was previously conducted for the proposed Browse Upstream LNG Development (DHI, 2011). This modelling assumed a cooling discharge rate of 325,000 m^3/day at a temperature of 45°C at 20 m depth through a 1.4 m diameter downward facing caisson. Therefore the modelling is broadly representative of below

water discharges from NRC (i.e. matching design capacity/characteristics) The model found that under varying set tidal current speeds, including worse case (0.12m/s) and typical current speeds (0.32 m/s), the thermal plume cooled to within 3°C of ambient within a short distance from the caisson (31 and 17 m respectively). These model results suggest that temperature of the NRC cooling water discharge plume would be reduced to less than 3°C above ambient well within 200m of the discharge point.

Modelling of the cooling water has been undertaken for the NRC (SKM 2009) for a discharge flow rate of 15,750 m^3/hr, which is slightly higher than the 15,180 m^3/hr generated by NRC seawater lift pumps (SKM 2009). Although the modelling study was not focused on reporting behaviour of the plume in terms of temperature dispersion, it can be inferred from the modelling results that the cooling water plume would be diluted several hundred fold at the 200 m from the discharge point each season (summer, winter, transitional), which further indicates cooling water is compliant with Woodside’s target.

Residual Biocide

Seawater used for cooling is treated with chlorine as sodium hypochlorite produced by electrolysis of seawater at the intake point as a means to prevent fouling growth within the cooling system pipe work. In seawater hypochlorite undergoes hydrolyse to yield hypochlorous acid, which is a weak acid and will undergo dissociation as shown by the formula below.

$$HOCl \rightarrow H^+ + OCl^-$$

The total residual chlorine level is measured on a weekly basis and the average concentration is in the order of 200µg/L. Chlorine is a strong oxidant and following discharge and dilution the residual hypochlorous acid will quickly react with inorganic constituents such as sodium, iron (II), nitrite and sulphide to produce chlorides, such as NaCl.

The current Australian guideline for total residual chlorine is 3µg/L (ANZECC/ARMANZ, 2000) however, this number is derived predominantly from freshwater data and consequently is a low reliability trigger value. The following PNEC values for Chlorine were derived from a literature review undertaken by CSIRO (SKM 2008), the “safe dilution” ratios were derived based on the average weekly measured concentration of 200 µg/L (**Table 12-6**).

Table 12-6: PNECs for Total Residual Chlorine (SKM, 2008)

Protection probability	PNEC (µg/L)	Safe dilution (assuming 200 µg/L discharge concentration
PC95(50)	5	40:1
PC95(50)	13	16:1

Modelling of the total residual chlorine has been undertaken for the NRC (SKM 2009). The North Rankin discharge has a typical total residual chlorine concentration in the range of 0.2 to 1 mg/L and was modelled with a discharge flow rate of 15,750 m^3/hr, which is slightly higher than the 15,180 m^3/hr generated by NRC seawater lift pumps.

A number of different scenarios were modelled with varying discharge concentrations and seasonal conditions likely to occur on the NWS. In all scenarios the modelled concentrations were below the PNECs for acute and chronic effects at 200 m distance from the discharge point.

The discharge of residual hypochlorous acid will not cause significant or unacceptable environmental impact due to the low concentration of discharge, rapid rate of reaction to non-harmful products and verily localised area of effect. Hence the environmental impact is considered to be acceptable.

Summary of Control Measures

- Chemical dosage of the reverse osmosis and cooling water systems is undertaken in a controlled manner to minimise dosage to the minimum required to achieve treatment efficiency.
- Cooling water discharge complies with Woodside’s Environmental Performance Operating Standard:
  - Temperature increase is to be less than 3 °C above ambient, 95% of the time at 200 m from the offshore discharge source (i.e. defined as the ‘approved mixing zone’).
- Compliance with the Offshore Marine Discharges Adaptive Management Plan:
  - Additional verification assessment or monitoring will be undertaken should there be potential for a change to discharge characteristics, which may alter existing compliance with the Performance Objective.

A- 12 Routine Discharges: Discharge of Brine

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Water Systems.	X									F	1	Low

Description of Source of Risk

Brine

The environmental risk is discharge of reject water from the NRC reverse osmosis (RO) plant causing physiological effect to marine biota.

Brine (saline wastewater from potable water production) is predicted to have a concentration of approximately 56 ppt and discharge volume of up to 75 m^3 per day. Water is supplied from the chlorinated seawater supply system prior to passing through a series of filters and reverse osmosis membranes. The process also includes dosing of anti-scalants as well as cleaning chemicals as part of the filtration process.

Potential Environmental Impacts

Value | **Description of Potential Environmental Impact**

Water Quality

The potential impacts of reverse osmosis (RO) brine have been subject to a considerable amount of study in recent times due to the large number of high volume desalination plants being constructed. As a result, the potential impacts can be considered to be well known.

The substantive potential impacts relate to effects caused by salinity. Other constituents, such as anti-scaling additives and antifouling additives, are not discharged during normal operations at levels that are likely to cause toxicity on marine biota (HydroBiology, 2006).

Marine organisms exist in osmotic balance with their marine environment and exposure to a rapid change in salinity has the potential to result in the dehydration of cells, decreasing turgidity with potentially lethal consequences. However, most marine species are able to tolerate short-term fluctuations in salinity of 20 to 30% (Walker and McComb, 1990). A review of 'safe dilution' values obtained for RO brine from recent projects has been compiled and is presented in **Table 12-7**. It can be inferred from these values that the 'safe dilution' of NRC RO brine would be in the order of 10 to 15:1 for PC95(50) and 15 to 20:1 for PC99(50).

Table 12-7: Calculated 'Safe Dilution' Ratios for Reverse Osmosis Brine

Location	Salinity (parts per thousand)	Safe dilution to achieve PC95(50)	Safe dilution to achieve PC99(50)
Perth [a]	65	12:1	15:1
Adelaide [b]	65	12:1	14:1
Melbourne [c]	65 to 70	n/d	20:1
Olympic Dam [d]	78	60:1	80:1

a: Yeates et al, 2006. b: South Australia Water 2008. c: VicWater 2012. d: Hydrobiology Pty. Ltd. 2006.

On discharge, the higher density RO brine plume will tend to sink in the water column and will be subject to rapid dilution and dispersion in the prevailing currents. Owing to the low discharge rate of 75 m^3 per day and given the understanding of dilutions achieved by marine discharges, it is likely that a 'safe dilution' would be rapidly achieved within a few metres of the discharge point and the potential for impact will be insignificant.

Summary of Control Measures

- Chemical dosage of the reverse osmosis and cooling water systems is undertaken in a controlled manner to minimise dosage to the minimum required to achieve treatment efficiency.

- Compliance with the Offshore Marine Discharges Adaptive Management Plan:
    - Additional verification assessment or monitoring will be undertaken should there be potential for a change to discharge characteristics, which may alter existing compliance with the Performance Objective.

A- 13 Routine Discharges: Discharge of Drainage Water

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Drainage Systems.	X									F	2	Low

Description of Source of Risk

The drainage system on the NRC consists of:

- Non-hazardous open drains, which collect from sources not containing hydrocarbons, diesel, lubricating or seal oils. The water collects in the non-hazardous open drain header and discharged directly to sea. Accidental hydrocarbon or chemical spills via this route are addressed in a separate risk assessment
- Hazardous open drains, which collect oily water from hazardous areas on the NRC, including wash down water and spillage of liquids on decks, equipment drip trays or bunded areas. The hazardous open drains collect in the hazardous open drains tank for gravity separation. Any residual oil is transferred to the iso-waste containers
- Hazardous closed drains system, which drain volatile hydrocarbon liquids from all process equipment and route them to the LP flare knock-out/closed drains drum (on NRA or NRB), with recovered liquids recycled back to the process via the flare drum knock-out pumps.

Drainage water from the open drains system is contained in the hazardous open drains tank prior to discharge to the marine environment. The water is treated by gravity separation prior to discharge. The OIW concentration of the water is monitored by an Advanced Sensor OIW analyser prior to discharge, which is manually calibrated with Horiba samples. In accordance with Woodside's Offshore Marine Discharges Adaptive Management Plan, water is only discharged to the marine environment if it has an OIW concentration less than 30 mg/L.

Liquid hydrocarbons separated in the drains tank are manually pumped out to waste oil containers for onshore disposal, in accordance with Woodside's Waste Management Plan for Offshore Facilities.

If there is a chemical or hydrocarbon spill on the NRC, the drainage water is contained in the hazardous open drains tank for transfer to a tote tank and disposal onshore in accordance with Woodside's Waste Management Plan for Offshore Facilities.

The flow through the closed drains system is directed to the closed drains drum for NRB and the flare KO drum for NRA. The liquids are returned to the oily water drains separator where the water and hydrocarbons are separated by gravity. The hydrocarbons are directed back to the process from this separator and the water is directed to the drains tank. The gases from the closed drains system are directed to the LP flare.

The environmental risk is the discharge of drainage water from the hazardous open drains to the marine environment causing a reduction in water quality and potentially toxic effect to marine biota.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality	The OIW concentration of discharge from the drains tank is monitored prior to release, and only water with an OIW concentration of less than 30 mg/L is released. Furthermore, the rapid dilution and dispersion of the discharge in the marine environment will minimise any potential risk and impact.

Summary of Control Measures

- Compliance with the NR Complex Performance Standard – Open Hazardous Drains (F22):
  - F22.1 - Open hazardous drains in safe and serviceable condition to contain leaks and spills.
  - Annual pre-cyclone cleaning and flushing.
  - 2 Yearly visual inspection of NRA Utility Hazardous Open Drains Systems, Open Drain Caisson and

Waste Oil System, NRB Hazardous Open Drains Collection and Caisson.

A- 14 Waste Management and Chemical Use: Hazardous and Non-hazardous Waste Handling and Disposal

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Operational Details • Production and Major Projects	X					X				F	1	Low

Description of Source of Risk

The environmental risk is incorrect disposal of waste leading to pollution of the marine environment or waste of resources. Normal operations on the NRC and support vessels result in a variety of hazardous and non-hazardous wastes. These materials could potentially impact the marine environment if incorrectly disposed or discharged in significant quantities. The planned Persephone project will include the removal of a redundant 12 inch rigid riser including onshore disposal.

Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard and scrap steel. Hazardous wastes include recovered solvents, excess or spent chemicals, oil contaminated materials (e.g. sorbents, filters and rags), batteries and used lubricating oils. Sand and sludges may also be generated during well clean-up operations and vessel maintenance. All waste materials, including hazardous wastes (i.e. liquid and solid wastes), generated on the NRC will be transported to shore for disposal or recycling by Woodside's licensed waste contractor.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality **Protected Species**	Improper management of hazardous or non-hazardous wastes may result in pollution and contamination of the environment. There is also the potential for secondary impacts on marine fauna that may interact with wastes, such as packaging and binding, should these enter the ocean. Marine fauna can become entangled in waste plastics and waste plastics can be ingested when mistaken as prey (Ryan et al, 1988). In order for an impact to occur, wastes would have to be released into the environment, thus the preventative management solution is to ensure there is no deliberate or inadvertent discharge of wastes during NRC operational activities. The environmental impact of the disposal of wastes in the described manner is a minor incremental increase in total waste received at the recycling/disposal facilities and is considered acceptable.

Summary of Control Measures

- Compliance with Woodside's Waste Management Plan for Offshore Facilities:
    - Waste will be stored and segregated, and handling equipment kept in good working order, to prevent accidental loss to the environment.
    - Records of waste transport, treatment, recycling or disposal will be maintained.
    - Wastes will be transported and disposed of in a safe and environmentally responsible manner that prevents accidental loss to the environment.
    - Training will be provided to relevant operational personnel to educate on the correct waste management requirements i.e. storage, handling, segregation and disposal.
- Compliance with Woodside's Environmental Performance Operating Standard:
    - Waste contractors will be audited to ensure they have the facilities and systems to be able to dispose of the waste in an environmentally responsible manner.

- For support vessels, compliance with MARPOL 73/78 Annex III: Packaged Harmful Substances (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983), Marine Orders - Part 94: Marine Pollution Prevention – Packaged Harmful Substances:
  - All solid, liquid and hazardous wastes (other than sewage, grey water and putrescibles wastes) will be sent ashore for recycling, disposal or treatment.
- For support vessels, compliance with MARPOL 73/78 Annex V: Garbage (as implemented in Commonwealth waters by the Protection of the Sea (Prevention of Pollution from Ships) Act 1983), Marine Orders - Part 95: Marine Pollution Prevention – Garbage:
  - No disposal of domestic wastes or maintenance wastes overboard from vessels.
  - All wastes (other than sewage, bilge water and putrescibles waste) sent ashore for recycling, disposal or treatment.

A- 15 Waste Management and Chemical Use: NORMs Handling and Disposal

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: - Sand Management		X			X					E	1	Low

Description of Source of Risk

The environmental risk is incorrect disposal of Naturally Occurring Radioactive Material (NORM) waste leading to pollution of the marine environment and potentially chronic and acute toxicity impacts on marine flora and fauna. Inappropriate disposal may have similar impacts to terrestrial flora and fauna, as well as impact on human health (depending on the composition of the NORMs) if people are inadvertently exposed to the material.

Potential Environmental Impacts

Value	**Description of Potential Environmental Impact**
Marine Sediment Quality **Other Habitats & Communities**	NORMs are sometimes present in components of petroleum and natural gas production facilities. NORMs can be associated with the presence of crude oil, produced water and natural gas. Where petroleum industry NORM is observed, it is primarily found in scale, sludge and sand. In some instances NORM is required to be removed as waste and managed appropriately. The NORM nuclides of primary concern in oil production are Radium-226 and Radium-228. These decay into various radioactive progeny, before becoming stable. Radium-226 and Radium-228 belong to the two principal radioactive decay series associated with NORMs in the oil and gas industry (Uranium-238 and Thorium-228 respectively) (Australian Petroleum Production and Exploration Association, 2002 and International Association of Oil and Gas Producers, 2008). The deposition of radionuclide's into waste streams requiring removal is most strongly correlated with the presence of formation water and associated salts which permit the formation of precipitates and subsequently deposit throughout the process system as solid wastes, such as scales and sludges. Sand production also has the potential to carry and accumulate small quantities of residual radioactive particles which then accumulate in the production system low points, separators and filters. The activity concentrations involved in these materials cover a very wide range: at the low end Radium-226 concentrations can be 0.1 to 10 Bq/g, while at the high end concentrations can exceed 10,000 Bq/g. To be classified as Radioactive Material applicable Threshold Activity Concentration Limits must be exceeded (Codes and Standards section below). The NRC facility production system is designed for routine on-line sand removal and disposal, and has design features to minimise sand production. The NRC basis of design assumed there is a low probability of sand production. Vessel entry and inspection for sand is carried out infrequently and to date, no sand has been removed from production vessels. To avoid build-up of calcium and bicarbonates, scale inhibitor is injected into the process on a continual basis during production, such that the amount of scale produced throughout the lifetime of the facility is considered negligible. Should NORM nuclide levels increase or be found to be above safe levels, proposed management will be in line with legislation and industry guidelines.

Summary of Control Measures

- If NORMS are identified, compliance with:
    - Commonwealth Radioactive Waste Management Act 2005;
    - National Radioactive Waste Management Bill; and
    - Code of Practice for the Safe Transport of Radioactive Material (Australian Radiation and Nuclear Protection Agency, 2008).
- The NRC wells are monitored by real-time clamp-on acoustic sand detectors and sand production is primarily

minimised by controlling wellhead pressures. The NRC production separators are designed for sand, sludge and slurry removal and disposal, during shutdown.

- Compliance with Woodside's Environmental Performance Operating Standard:
    - Hazardous waste including NORMS will be handled, stored and disposed of to prevent pollution or contamination of soil and water.
    - Waste contractors will be audited to ensure they have the facilities and systems to be able to dispose of the waste in an environmentally responsible manner.
- Compliance with Woodside's Waste Management Plan for Offshore Facilities:
    - NORMs will be stored in a designated labelled radioactive storage bin and transported by a licensed carrier to an appropriate onshore disposal facility.
    - Should it become necessary to dispose of waste containing NORMs, a specific risk assessment will be undertaken addressing disposal methods and fate that is consistent with regulatory guidelines and best practice.

A- 16 Waste Management and Chemical Use: Chemical Selection and Usage

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Hydrocarbon and Chemical Inventories and Selection • Subsea Inspection, Maintenance and Repair Activities	X					X				F	2	Low

Description of Source of Risk
Chemical usage is required for various routine and non-routine process or maintenance applications on the NRC and as such chemicals may be present in waste water streams which are discharged to the marine environment. There is also the potential for discharge of chemicals to the marine environment via accidental (e.g. spills) or non-routine discharges (e.g. periodic maintenance requirements). In addition, the NRC will contain small or very small quantities of other chemicals from time to time for various operational and/or maintenance purposes. Facility maintenance chemicals undergo an assessment process as described in Woodside's Chemical Management Procedure. This procedure also addresses the health and safety aspects of chemical selection, assessment and approval. All operational chemicals (process and non-process), will be selected, assessed and approved in accordance with the Woodside Environment Procedure for Offshore Chemical and Assessment. The selection of operational process chemicals is also undertaken in accordance with the Production Chemistry – Process Chemical Selection and Technical Approval Procedure.

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Water Quality **Protected Species**	Bulk chemicals used on the NRC generally have a low impact on the marine environment as a result of Woodside's preference towards chemicals with low toxicity that still meet the technical needs of their application. Chemicals with certain agents (e.g. surfactants or elements that bio-accumulate) can have a higher impact and are therefore limited in use and volume to the lowest practically required to either complete a task, or meet the operational needs of the facility, if they cannot be eliminated from use entirely. Most chemicals selected for use in the process or on the facility are water soluble. As such, emphasis is placed on minimising volumes if possible; ensuring storage integrity is high and providing containment in the event of a spill. Once spills of non-hydrocarbon chemicals enter the water, they are effectively impossible to recover. Monethylene Glycol (MEG) and TEG are used for hydrate control and are added to the well fluids and will eventually be discharged via the PW system. MEG and TEG are ranked E on the OCNS list of Non-CHARMable products, which is the lowest (i.e. most environmentally benign) ranking possible. Both products are non-hazardous and readily biodegradable. Demulsifier is used to counteract the natural surfactants present, wetting agents or other chemicals used to assist separation of oil-in-water emulsions. Nalco is currently further testing this chemical and are anticipating a biodegradability result of greater than 20%. Lubrication oil will be used mainly within the diesel generators, and will thus require transport to the facility from shore and handling on support vessels and the facility. Lubrication oil is also frequently used in support vessel equipment (e.g. generators and engines). The impact of lubrication oils on biota, if spilt in large amounts, can be considered broadly in line with impacts from diesel and well fluids and are discussed in a separate risk assessment. Water foaming agents used in fire fighting (AFFF), by nature of the surfactant properties by which it effectively extinguishes liquid fires, can be particularly harmful to aquatic organisms within

	freshwater environments like ponds and streams. Offshore however, this surfactant effect is greatly diminished (due to wave and wind action) and does not present the same risks to pelagic fish and other marine life. The use of these materials outside an emergency situation is restricted to testing activities required to ensure safe and effective operation of the system in an emergency. Biocides are also used on NRC to prevent the bacterial growth in pipelines that may cause corrosion. Oxygen Scavenger is used to de-oxygenate lines and prevent corrosion and aerobic bacterial growth. Various acids (e.g. sulphamic acid) may be required for maintenance activities associated with wells and process equipment, such as for removal of solid materials such as calcium carbonate. The resulting discharge of any such acids is unlikely to cause any detectable change in pH of the surrounding waters due to the strong buffer capacity of seawater. According to the Worksafe Australia criteria, sulphamic acid diluted with water to a concentration of 20% is non-hazardous. It is similar to other weak acids such as lemon juice or vinegar. Based on US EPA ratings (Pesticides Action Network North America, 2011), the aquatic ecotoxicity of sulphamic acid is rated as 'slightly toxic' (LC50 10,000-100,000). Observations during previous use of acids for such activities identified no noticeable effect to marine life or the marine environment. This included observing large and small fish species swimming in the vicinity of the work both during and after cleaning. Chemical dyes are used to identify the source of a flow or pipeline leak. Fluorescein liquid dye has a Gold CHARM rating but carries a CEFAS substitution warning. Fluorescein is non-toxic at the concentrations utilised. During discharge the dye will cause temporary localised discolouration in the immediate vicinity of the release, however as the dye is water soluble, it will rapidly disperse in the marine environment. The material used in grout, mattresses and rock is typically concrete-based and has a Group E OCNS rating. This is the lowest (i.e. most environmentally benign) ranking possible indicating this product is non-hazardous. Staurolite products are used for abrasive/sand blasting to clean and remove marine growth. The main component is staurolite which is a naturally forming silicate mineral and non-toxic. All other chemicals used on the facility and support vessels could present an array of consequences for specific biota if released to the environment depending on the nature and degree of exposure received by a particular individual. However, all non-process chemicals present on the facility are either of very minor quantity (usually less than 50 litres) or likely to have little to no effect in the marine environment, particularly at the facility location (given the distance to sensitive shallow water habitat, depth of water at the facility, high rates of mixing).

Summary of Control Measures

- Compliance with Woodside's Production Chemistry – Process Chemical Selection and Technical Approval Procedure:
  - Selection of operational process chemicals will include consideration of technical, commercial, health, safety and environment parameters.
- Compliance with Woodside's Environment Procedure: Offshore Chemical Selection and Assessment, for selection of operation chemicals (process and non-process) which includes:
  - Where chemicals are rated Gold, Silver, E or D on OCNS with no substitution warnings, they may be approved for use, providing they are used as detailed in the relevant contractor procedure.
  - Chemicals with OCNS rating other than Gold, Silver, E or D or those which have a substitution or product warning require an ALARP demonstration before use. The ALARP demonstration will include:
    - Details of the chemical application (volumes, concentration, location)
    - Ecotox data
    - Fate of the chemical
    - alternatives available to the Global and Australian market
- Compliance with Woodside's Chemical Management Procedure, for the selection of facility maintenance chemicals.
- Compliance with Woodside's Environmental Performance Operating Standard:
  - Chemicals will be stored safely and handled to prevent the release to the marine environment.
  - Facilities will maintain a hazardous chemicals register.

  - Select chemicals with lowest practicable environmental risks subject to technical and economic constraints.
  - All chemicals which do not meet the initial screening criteria stated in the Woodside Environment Procedure for Offshore Chemical and Assessment and require ALARP demonstration are to be recorded in the NRC Production Offshore Process and Subsea Chemical Register. The register will be reviewed on an annual basis.

Unplanned Activities (Accidents / Incidents / Emergency Situations)

A- 17 Introduction of Invasive Marine and Terrestrial Species: Introduction of Invasive Marine Species

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Support vessels					X					E	1	Low

Description of Source of Risk

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

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

Cargo and vessels themselves can host invasive terrestrial species, which may range from the microscopic and small species (including bacteria, mites and insects etc.), to larger species including birds, rats, snakes and lizards. Packing material and foodstuffs was a common vector for importation of invasive terrestrial species, prior to implementation of international conventions to manage these materials. Vessels can be subject to boarding by larger species (particularly birds, rats and reptiles) with loaded cargo, during quieter periods alongside a wharf (e.g. overnight) or in transit (as a resting place for birds).

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Other Habitats & Communities	Transport between two areas of indigenous (local) marine or terrestrial organisms is of little to no environmental concern. Species from international locations, or species originating from international locations (that may have been transferred to a local area), may not be compatible with the local environment. Of particular concern are invasive marine species and all terrestrial species. Introducing invasive marine species into the local marine environment will alter the ecosystem, as invasive species have characteristics that make them superior (in a survival and/or reproductive sense) to the indigenous species. They may predate on local species (which had previously not been subject to this kind of predation and therefore not have evolved protective measures against the attack), they may outcompete indigenous species for food, space or light and can also interbreed with local species, creating hybrids such that the endemic species is lost. Invasive marine species 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). Introduced marine species 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. Terrestrial species have similar types of impacts to invasive marine species, however, all non-indigenous terrestrial species are subject to stringent controls on importation and cargo subject to stringent quarantine procedures and requirements, due to Australia's unique environment and long period of isolation from other continental land masses which leaves indigenous species and ecosystems particularly vulnerable to impact. Effects on commercial interests can be particularly damaged by importation of certain species (e.g. pathogens, fruit flies and termites) which may result in both lost production and restrictions on trade with other areas and countries.

Summary of Control Measures
• Compliance with Biosecurity Act for Australian Ballast Water Management Requirements, aligned with the International Convention for the Control and Management of Ships' Ballast Water and Sediments) o As a minimum, all vessels mobilised from outside of Australia will undertake ballast water exchange > 12 nm from land and > 200 m water depth. • Compliance with Woodside's Invasive Marine Species Management Plan (Woodside Doc. A3000AH4345570) to minimise the risk of introducing invasive marine species into areas where the Company operates: o An IMS risk assessment will be undertaken on all support vessels for the NRC that propose to enter and operate within nearshore waters around Australia. Nearshore areas include all waters within 12 nautical miles of land and in all waters less than 50m deep at LAT; and o As specified in Woodside's IMS Management Plan, an IMS risk assessment is not required in the below circumstances: ▪ Vessels that do not plan to enter and operate within nearshore waters (within 12 nautical miles of land and in all waters less than 50m deep at LAT); and o Locally sourced vessels, where the same supply facilities/port have been used since the last IMS inspection or clean. • Compliance with the Biosecurity Act (2016)): o Where vessels arrive from international destinations, either the vessel will be cleared by Biosecurity Officer prior to commencing work (allowing unrestricted interaction with other, local, work vessels) or quarantine items will be clearly identified and managed to avoid inadvertent transfer to a local vessel or to shore.

A- 18 Non-routine / Accidental Atmospheric Emissions: Venting of Hydrocarbon Gases

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Topsides • Process Description • Facility Operations • Hydrocarbon and Chemical Inventories.			X							F	2	Low

Description of Source of Risk
Displaced hydrocarbon vapours are discharged from the platform diesel tanks and other LP hydrocarbon containing sources (e.g. drains caissons, open drains sources) to atmosphere. Other sources of venting may include vessel maintenance activities (i.e. purging/draining when flare route is unavailable). Venting of gas via the flare may also occur during severe weather events (e.g. flame outage during cyclones).

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Air Quality	Venting will release unburnt hydrocarbons into the atmosphere, including minor quantities of Volatile Organic Carbon (VOCs) and other constituents. The venting of hydrocarbons has a greenhouse intensity higher than if the same gas was flared. Venting from the NRC represents only a minor source of atmospheric emissions, and in addition to the distance from shore, will not result in major effects on either local or global hydrocarbon or greenhouse gas concentrations.

Summary of Control Measures

- Compliance with Performance Standard P25 Purge Gas and Blanketing System to ensure the system is operated within the design specifications.
- The NRC flare systems are designed to prevent the need for cold venting; and
- Process controls, alarms and safety shutdown devices are in place.

A- 19 Non-routine / Accidental Atmospheric Emissions: Release of Synthetic Greenhouse Gases and Ozone-depleting Substances

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • HVAC System • Support Vessels			X							F	1	Low

Description of Source of Risk

Heating, ventilation and air conditioning (HVAC) and refrigeration systems on the NRC use various refrigerant gasses including R134a, R22, R410a, R404a and R407c. All these refrigerants have no ozone depleting potential with the exception of R22 is considered to have a low ozone depleting potential. R410a R134a, R22, and R407c are considered to have moderate Global Warming Potentials (2050 1300, 1500 and 1600 respectively) while R404a is considered to have a higher Global Warming Potential (3922). The facility may vary stocks of refrigerants as required in the future and has a refrigerant register where accurate records of refrigerants held are maintained.

Potential Environmental Impacts

Value	**Description of Potential Environmental Impact**
Air Quality	Ozone Depleting Substances (ODS) attack the ozone layer, a thin veil of O_3 in the upper atmosphere that acts to block ultra-violet (UV) rays from reaching the surface of the earth. The NRC only uses substances with low to no ozone depleting potential. Furthermore, the use and disposal of ozone depleting and synthetic greenhouse gas refrigerants is regulated by Australian legislation. Use within support vessels is also regulated by international agreements (including a phase-out process for substances with higher ozone depletion potential).

Summary of Control Measures

- Compliance with Woodside's Offshore Refrigerant Management Plan, specifically:
    - Woodside will hold a valid Refrigerant Trading Authority;
    - Refrigerant systems will be maintained by qualified licensed technicians; and
    - Records of refrigerant inventories and equipment maintenance will be documented.

A- 20 Non-routine / Accidental Hydrocarbon or Chemical Spills: Chemical Spill from Facility or Support Vessels

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Hydrocarbon and Chemical Inventories and Selection • Subsea Inspection, Maintenance and Repair Activities • Support Vessel Operations.	X									F	2	Low

Description of Source of Risk
The environmental risk is the accidental release of chemicals to the marine environment from storage, use or during transfer of chemicals to the NRC or from support vessels.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality	All chemicals used on the NRC or support vessels could present an array of consequences for specific biota if released to the environment, depending on the nature and degree of exposure received by a particular individual. However, all operational non-process chemicals and maintenance chemicals present on the NRC and support vessels are either held in low quantities (usually less than 50 L) or likely to have little to no effect on the marine environment if spilled, particularly within the NRC Operational Area given the distance to sensitive shallow water habitat, depth of water and high rates of mixing. Operational process chemicals on the NRC which are kept in larger quantities are stored in dedicated vessels (usually tote tanks) which have similar controls of those related to mitigating hydrocarbon spills (e.g. permanent bunding, permanent piping to the process, isolatable by valves etc.). TEG is the process chemical kept in the largest volume on the facility (35 m3) (Section 3.6.6.2). TEG is of low toxicity to the environment (PLONAR Substance), with an OCNS Rating of E. Support vessels used for IMR activities will require storage of small quantities of lubricating oils and hydraulic fluid on the vessel, which have the potential to spill if not appropriately managed. Hydraulic fluid may also potentially be spilled from a leak in hoses or lines on hydraulic equipment such as cranes or winches. The subsea equipment associated with IMR activities contain a relatively small volume of hydraulic fluid and there is a potential for hoses and seals to fail during subsea operations resulting in a loss of hydraulic fluid to the marine environment. In the event of a hydraulic hose failure volumes of around 25 L have historically been released.

Summary of Control Measures

- Compliance with Woodside’s Environment Procedure: Offshore Chemical Selection and Assessment, for selection of offshore process chemicals (process and non-process which includes:
    - Where chemicals are rated Gold, Silver, E or D on OCNS with no substitution warnings, they may be approved for use, providing they are used as detailed in the relevant contractor procedure.
    - Chemicals with OCNS rating other than Gold, Silver, E or D or those which have a substitution or product warning require an ALARP demonstration before use. The ALARP demonstration will include:

        - Details of the chemical application (volumes, concentration, location)
        - Ecotox data
        - Fate of the chemical
        - alternatives available to the Global and Australian market

- Facility maintenance chemicals undergo an assessment process as described in Woodside's Chemical Management Procedure.
- Compliance with Woodside's Environmental Performance Operating Standard:
    - Chemicals will be stored safely and handled to prevent the release to the marine environment.
    - Facilities shall maintain a hazardous chemicals register.
    - Select chemicals with lowest practicable environmental risks subject to technical and economic constraints.
- Support vessels will have onboard a current Shipboard Oil Pollution Emergency Plan (SOPEP) to respond to chemical spills.
- IMR Activity related support vessels
    - Any chemical storage above deck must be designed and maintained to have at least one barrier (i.e. form of bunding) to contain and prevent deck spills entering the marine environment. This can include containment lips on deck (primary bunding) and/or secondary containment measures (bunding, containment pallet, transport packs, absorbent pad barriers) in place.
    - Equipment located on deck utilising hydrocarbons (e.g. cranes, winches or other hydraulic equipment) will be maintained to reduce risk of loss of hydrocarbon containment to the marine environment.
    - Spill response bins/kits are maintained and located in close proximity to hydrocarbon storage areas and deck equipment / bunkering areas for use to contain and recover deck spills.
- Equipment for IMR activities:
    - Subsea equipment utilising hydrocarbons will be maintained to reduce the risk of loss of hydrocarbon containment to the marine environment.
    - In ocean equipment (subsea equipment and towed equipment) utilising hydrocarbons will be inspected to ensure equipment is not leaking and critical hydraulic hoses are in good working order prior to deployment.

A- 21 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release during Bunkering Operations

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Diesel Bunkering and Usage	X					X				E	2	Medium

Description of Source of Risk

Bunkering of diesel has the potential to result in an accidental spill of diesel to the marine environment. Key sources of risk include damage to or failure of bunkering hoses, dry break couplings, tanks or connections. This may result from poor inspection and maintenance, loss of control on the supply boat (loss of vessel separation), inclement weather and operator error. Note that the potential risks associated with rupture of vessel or platform diesel tanks are addressed in the risk assessments for Topsides Loss of Containment and Loss of Marine Vessel Separation.

Spill Volumes: Although large volumes of diesel are involved in bunkering operations (supply vessel storage and NRC tank storage volumes), a spill is most likely to be less than 200 L as a result of pin-hole leaks in hoses or spills occurring during decoupling. However, the worst case credible spill scenario could result in up to 8 m^3 of diesel being discharged to the marine environment. This scenario represents a complete failure of the transfer hose combined with a failure to follow procedures during bunkering activities, which require continual monitoring. The 8 m^3 spill scenario represents a rupture of the hose and pumping being continued for five minutes until the failure is identified and the supply shut-off.

Fate and Trajectory: Marine diesel is a mixture of both volatile and persistent hydrocarbons. Predicted weathering of diesel, based on typical conditions in the region, indicates that 45% by mass is predicted to evaporate over the first day or two (**Figure 12-3**).

Spreading rates of spilled diesel are typically 2 to 7 metres/minute depending upon spill volume and the current sea state (APASA, 2006 and 2008). For the environmental conditions experienced near the NRC, diesel is expected to undergo rapid spreading and this, together with evaporative loss, will result in a rapid slick break up. Diesel distillates tend not to form emulsions at the temperatures found in the region.

Diesel spill modelling undertaken for a small diesel spill (8 m^3 released in under 10 minutes) at the GWA platform, located 25 km south west of the NRC (APASA 2013b) which is representative of the same spill volume at NRC where metocean conditions are similar, indicated no potential contact with the shoreline sensitive receptors. Modelling indicated the potential for exposure at concentrations exceeding 10 g/m^2 are confined to within 1 km from the release site. Therefore, there is no potential for contact with sensitive receptor locations or to extend beyond a localised area around the facility.

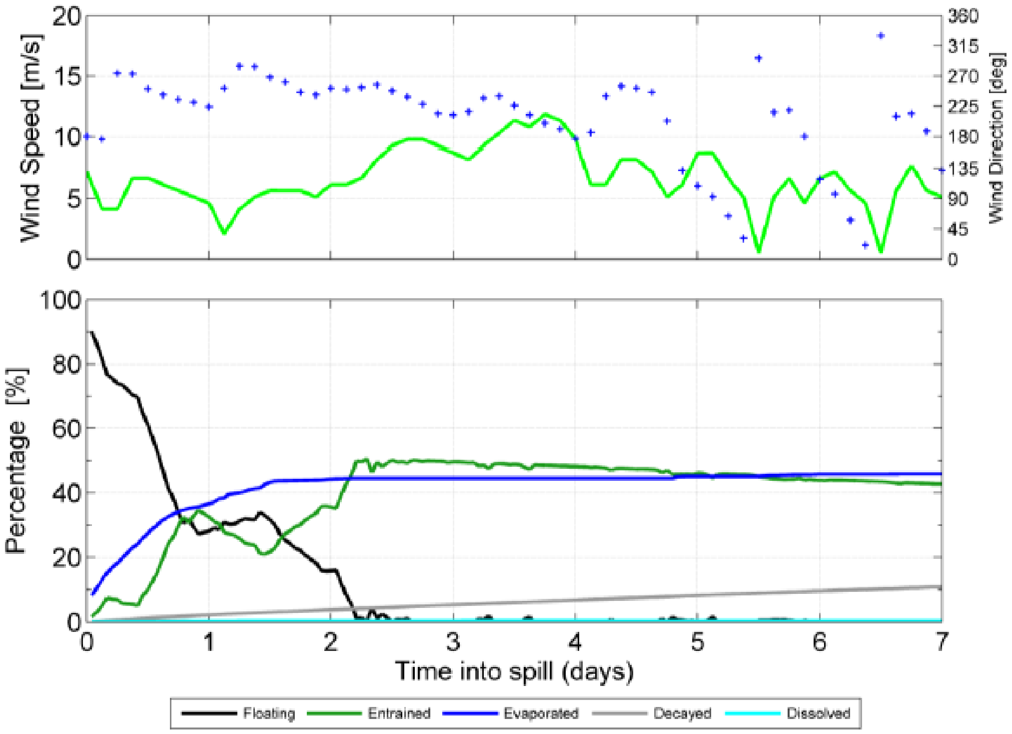


Figure 12-3: Proportional mass balance plot representing the weathering of marine diesel spill onto the water surface as a one-off release (50 m^3 over 1 hr) and subject to variable wind at 27 °C water temperature and 25 °C air temperature

Potential Environmental Impacts

Value	**Description of Potential Environmental Impact**
Water Quality **Protected Species**	The toxic components in diesel include alkylated naphthalenes which can be rapidly accumulated by marine oysters, clams, shrimp, and fish etc. Diesel also contains additives that contribute to its toxicity. A spill of diesel from bunkering at the NRC facility will have an acute impact on the water column biota in the immediate vicinity of the spill. However, given the predicted spreading and break-up of the spill, this impact will be localised and temporary. Given the approximately 125 m water depth at the NRC facility location, a surface spill of diesel will not impact directly on the seafloor benthos.

Summary of Control Measures

- Compliance with North Rankin Redevelopment Project Integrated Diesel System – Start-up and Operating Guide and Receiving Diesel Fuel from Supply Vessel which details bunkering procedures. Key requirements include:
    - Bunkering will only proceed in acceptable sea state conditions.
    - Communications between the supply vessel and facility bunker station will be maintained during bunkering.
    - Hoses, couplings and sea surface will be visually monitored during refuelling.
    - Tank levels will be monitored continuously on the facility.
    - Bunkering will be undertaken under an approved loading plan, agreed between the supply vessel and facility.
    - Spill clean-up equipment will be available in proximity to the bunker station.
- Support vessels will have onboard a current Shipboard Oil Pollution Emergency Plan (SOEP) for responding to small diesel spills.

A- 22 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by a Well Loss of Containment

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Well Configuration • Subsea Infrastructure.	X	X	X	X	X	X		X	X	B	1	High

Description of Source of Risk

A loss of well integrity/control is an uncontrolled release of reservoir gas or other well fluids to the surface, resulting from an over-pressured formation fluid (gas or other fluids). The release of hydrocarbons as a result of a well loss of containment is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons in wellheads, manifolds and trees for subsea and platform wells connected to the NRC Platform.

A decision type 'B' has been applied to this risk under the *UKOOA 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 including the bowtie methodology and oil spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation.

Credible Scenarios

There are two potential environmental consequences related to the release of hydrocarbons caused by a well loss of containment:

- a hydrocarbon release from a platform well to the marine environment and atmosphere; or
- a hydrocarbon release from a subsea well to the marine environment and atmosphere.

These consequences will result in the release of hydrocarbons in the form of gas and condensate. The credible spill volume for a hydrocarbon release is approximately 27,512 m^3 (platform well event) and 122,167 m^3 (subsea well event) of NWS condensate over 77 days during production operations. The hydrocarbon discharge rates are based on the average flow rate of an uncontrolled well over a 77 day period (**Table 12-8**).

Table 12-8: Maximum release rate of hydrocarbons as a result of well loss of containment from the NRC

Well	Gas to Condensate Ratio	Gas Volume	Condensate Volume	Expected flow rate
PEN05	stb/MMscf	20,944 MMscf over 77 days	27,510 sm^3 over 77 days	375 m^3/day
Subsea well PSA-G	stb/MMscf	27,991 MMscf over 77 days	122,167m^3 over 77 days	375 m^3/day

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality **Marine Sediment Quality** **Air Quality** **Marine Primary Producers** **Other Habitats & Communities** **Protected**	To assess the potential impacts from a well loss of containment event, this section discusses the outcomes of oil spill trajectory modelling which has been undertaken which supports the NRC EP (including the addition of subsea wells for PSP). It focuses on defining the furthest (i.e. worst case) possible extent from the release location that could be reached by condensate at or above a particular threshold if the spill scenario occurred. Potential biological and ecological impacts including; impact to sensitive marine environments, protected species, Commonwealth Marine Reserves (CMRs). **Persephone Subsea Well Blow Out Assessment** NRC is the only North West Shelf facility which does not have subsea wells to prior to the tieback of Persephone. To understand the risk presented from the new subsea wells, Woodside have

Species
Socio-economic
Protected Areas

drawn upon data available from other facilities which have existing subsea well tiebacks and analysed the specific characteristics of a Persephone well blowout (**Table 12-9**). A hydrocarbon release caused by a well loss of containment for both NRC platform wells and subsea wells have the same consequence rating B (Woodside Operational Risk Table) which would result in serious long term impact on ecosystems, species and habitats. The likelihood loss of well loss of containment from a Persephone subsea wells is selected as 'highly unlikely' which is consistent in operational mode across all of Woodside facilities. Hydrocarbon release caused by a well loss of containment for both NRC platform wells and subsea wells have the same consequence rating B (Woodside Operational Risk Table) which would result in serious long term impact on ecosystems, species and habitats. The likelihood loss of well loss of containment from a Persephone subsea wells is selected as 'highly unlikely' which is consistent in operational mode across all of Woodside facilities.

Hydrocarbon modelling from the Persephone "surface and subsea blowout during a drilling campaign" discussed in **Table 12-9** has been further discussed below.

Table 12-9: Woodside NWS facilities - Hydrocarbon Release Caused by a Well Loss of Containment

Woodside Facility	**Scenario**	**Hydrocarbon**			**Decision Type**	**Consequence**	**Likelihood**
		Gas (MMscf over 77 days)	**Liquid(m^3 over 77 days)**	**Residual %**			
Goodwyn Alpha	Well blowout at surface	11, 011	245 078	5	B	B	1
	Well blowout at the seabed	24, 640	117 520	0.7	B	C	1
North Rankin Complex	Blowout at the surface	20, 944	27 510	0.1	B	B	1
Persephone	Development Well Credible scenario***	27, 991	122 167	1.8	B	B	1
	Surface and subsea blowout during a drilling campaign	95, 275	219 756*	1.8	B	B	2
Okha**	Well blowout at Seabed	19, 000	273 000	13	B	B	1
Angel	Well blowout at seabed	25, 179	166 372	0.5	B	B	1
Pluto	Surface and subsea blowout.	40, 810	77 859*	1.6	B	B	1

* Combined surface and subsea volume

** Okha is light crude, all the other facilities are condensate

*** Development well credible scenario volumes has not been assessed as part of this EP submission

Stochastic Modelling Methodology

For this EP, a comprehensive stochastic modelling study was undertaken of a potential subsea well loss of containment scenario. Other credible spill scenarios studied are provided in separate risk assessments.

Quantitative spill modelling was undertaken by APASA, on behalf of Woodside, using a three-dimensional oil spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific oil types under the influence of changing meteorological and oceanographic forces.

A stochastic modelling scheme was followed in this study, whereby SIMAP was applied to repeatedly simulate the defined spill scenarios using different samples of current and wind data. These data samples were selected randomly from an historic time-series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of percentage probability of contact at identified thresholds around the hydrocarbon release point.

The Zone of Consequence (ZoC)

- Surface Oil: In the event this scenario occurred, a surface hydrocarbon slick would form down current of the well site with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of surface hydrocarbon concentrations above the 10 g/m2 threshold concentration are mainly offshore areas within 50 km of the release, however, the model predicting isolated instances of slicks above threshold concentrations occurring up to approximately 660 km away, with potential to contact the Shark Bay region, depending on the prevailing wind and current conditions.
- Accumulated Hydrocarbons: Oil spill modelling results show that hydrocarbons have the potential to accumulate ≥ 100 g/m2 at Barrow Island (107 g/m2), Ningaloo Coast Middle (713 g/m2) and South (335 g/m2).
- Entrained Oil: In the event this scenario occurred, a plume of entrained hydrocarbons would form down current of the well site with the trajectory dependent on prevailing current conditions at the time. The modelling indicates locations within reach of entrained hydrocarbon concentrations above the 500 ppb threshold concentration are mainly offshore areas extending up to approximately 600km to the north east and 900 km to the south west, with the potential to contact sensitive receptors as far north as the Rowley Shoals, and as far south as the Abrolhos Islands, depending on the prevailing wind and current conditions. Further analysis of the entrained hydrocarbon results shows that exceedance is mainly in the top 40m of the water column, although there is a lower probability of exceedance up to 40 m water depth at shoreline and shoal receptors to the south west of the release site.
- Dissolved Aromatics: In the event this scenario occurred, a plume of dissolved oil would form down current of the well site with the trajectory dependent on prevailing current conditions at the time. The modelling indicates locations within reach of dissolved oil concentrations above the 500 ppb threshold concentration are confined to offshore areas extending up to approximately 400 km to the south west and 200km to the north and northeast. Sensitive receptors as far northeast as the Glomar Shoals, and as far south as the Ningaloo Coat have the potential to be contacted above set thresholds, depending on the prevailing wind and current conditions.

Potential Impacts to Air Quality

A well blowout has the potential to result in temporary reductions in local air quality and will contribute to global greenhouse gas emissions. Elevated methane levels will occur in the immediate vicinity of the surface expression of the gas release and the weathering of surface hydrocarbons will also result in elevated levels of volatile organic compounds (VOCs).The ambient concentrations of methane and VOCs released from diffuse sources is difficult to accurately quantify, although their behaviour and fate is predictable in open offshore environments as it is dispersed rapidly by meteorological factors such as wind and temperature.

VOC emissions from a hydrocarbon release in such environments are rapidly degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. Other hydrocarbons are likely to be quickly dispersed and any impacts on local air quality will be minor and temporary.

Due to the unlikely occurrence of a well blow out; the temporary nature of any hydrocarbon or VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a well blow out); 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 – 130km away), the potential impacts to air quality are expected to be minor and temporary.

A well blowout would also result in greenhouse gas emissions to the atmosphere, mainly from methane and CO_2. The impact of each greenhouse gas is measured in terms of its Carbon Dioxide equivalence ($CO_{2\text{-e}}$). Conservative estimates, which assume all gas released subsea and at the surface from a well blowout enters the atmosphere, would result in a maximum of approximately 10 Mt of $CO_{2\text{-e}}$ or an additional 1.75% of Australia's annual greenhouse gas emissions (DCCEE, 2012).

The environmental impact associated with these greenhouse gas emissions is difficult to quantify due to the global nature of greenhouse gas emissions and climate change. However, due to the unlikely occurrence of a well blowout, and the relatively minor increase in global greenhouse gas emissions, the potential impacts associated with greenhouse gas emissions from a well blowout are expected to be minor.

Gas releases due to trunkline loss of containment will be of a shorter duration and result in a lower total release volume; the potential impacts of these releases will therefore be significantly reduced when compared to blowout release described above.

Potential Impacts in Open Water

In the unlikely event of a major hydrocarbon spill from the NRC facility, megafauna such as marine mammals, marine reptiles and seabirds may be present in the spill affected area. This spill will potentially expose the fauna to surface, entrained or dissolved hydrocarbons, resulting in physical oiling and toxicity effects.

Modelling of oil spill scenarios indicate that surface slicks and entrained hydrocarbons could be far-reaching, as hydrocarbons have the potential to be transported over long distances. The modelling predicted a surface slick exceeding the 10 g/m^2 threshold could occur up to 50 km in the event of loss of well containment, 80 km in the event of a subsea loss of containment, 85 km in the event of a topsides process loss of containment and 140 km in the event of a topsides non-process loss of containment with the ZoCs mainly confined to deep ocean offshore waters.

Marine Megafauna – Marine Mammals

In the event of a major spill, there is potential surface and entrained hydrocarbons exceeding threshold concentrations will drift across the migratory routes of EPBC Act listed whale species, including humpback whales and pygmy blue whales (north and south bound migrations). For example, a major spill in July to October would coincide with humpback whale migration (including the humpback migration BIA) within the broader ZoC) through the waters off the Pilbara, North West Cape (Ningaloo), Shark Bay (open ocean) and North West Cape. A major spill in April to August or October to January would coincide with and potentially spatially overlay with the BIA for pygmy blue whale migration BIA.

Marine mammals are highly mobile and a number of field and experimental observations indicate whales and dolphins may be able to detect and avoid surface slicks. Marine mammals that have direct physical contact with surface slicks and entrained oil may suffer surface fouling or ingestion of hydrocarbons and inhalation of toxic vapours. Marine mammals that have direct physical contact with surface slicks and entrained oil may suffer surface fouling or ingestion of hydrocarbons and inhalation of toxic vapours. This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system or neurological damage (Etkins, 1997; IPIECA, 1995). For example, fouling of whale baleen (eg, humpback and pygmy blue whales) may disrupt feeding by decreasing the ability to intake prey. If prey (fish and plankton) is also contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs). Feeding appears to be rare during humpback whale migration so the potential for impact associated with ingestion of hydrocarbons may be low. Toothed whales, including dolphins, are ‘gulp-feeders’ targeting specific prey at depth in the water column away from the surface slick and are likely to be less susceptible to the ingestion of hydrocarbons. Cetaceans may exhibit avoidance behaviour and move away from the spill-affect area. Furthermore, given cetaceans are smooth skinned and hydrocarbons would not tend to adhere to body surfaces, the likely biological consequences of physical contact with surface hydrocarbons is likely to be in the form of irritation and sublethal stress.

Marine Megafauna – Seabirds

Various seabird BIAs are present within the wider ZoC. Offshore islands are potential breeding grounds with the surrounding waters providing foraging grounds for seabirds, which are vulnerable to contacting surface slicks during feeding or resting on the sea surface. Seabirds generally do not exhibit avoidance behaviour to floating oil. Physical contact of seabirds with surface slicks is by the primary exposure pathways of immersion, ingestion and inhalation. This may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (AMSA, 2012; IPIECA, 2004) resulting in mortality due to oiling of feathers or the ingestion of hydrocarbons. Longer term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chicks (AMSA, 2012).

Marine Megafauna – Marine Reptiles

Adult sea turtles exhibit no avoidance behaviour when they encounter a hydrocarbon surface slick (Odell and MacMurray, 1986). Contact with surface slicks 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 (Etkins, 1997). 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 crude oil may affect the functioning of their salt gland (Lutcavage et al, 1995). Hydrocarbons on 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 oil spill (Milton and Lutz, 2002). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (Etkins, 1997 and IPIECA, 1995). Ingested tarballs of residual weathered crude oil that are mistaken for food may also impact turtles through blockage and injury to the digestive tract and buoyancy problems due to build-up of fermentation gases (NOAA, 2010c), however NWS and Perseus condensates will not tend to form tarballs due to the low content of residual oil fraction (0.2% and 0.1% respectively).

There are BIAs present in the wider ZoC for Marine turtles indicating that they may be present in offshore open waters, however, the offshore waters within the ZoC are distant from emergent features and individual marine turtles are likely to occur in low densities. Whether sublethal or lethal effects occur will depend on the weathering state of the condensate and its inherent toxicity, particularly, given the potential geographical range of hydrocarbon contact and proximity to known major rookery sites (ie four of the marine turtle species (Green, Loggerhead, Flatback and Hawksbill) have nesting beaches along the mainland coast and islands in the region including the Montebello Islands, Barrow Island, Dampier Archipelago, Muiron Islands, the North West Cape and Ningaloo Reef.

Impacts to sea snakes from direct contact with the oil at the surface would result in similar physical effects to those recorded for turtles and would include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (Etkins, 1997). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the oil, resulting in damage to their respiratory system.

Plankton Populations

Plankton refers to marine flora and fauna that comprise the primary producing phytoplankton (cyanobacteria and other microalgae) and secondary consuming zooplankton (animal) comprising crustaceans (copepods), and eggs and larvae of fish and invertebrates (meroplankton). Primary productivity, ie, plankton blooms are triggered by sporadic upwelling events in the offshore waters of the NWS and such events are a key foundational trophic function group that support the region’s marine ecosystems. 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, 1998). Phytoplankton may also experience decreased rates of photosynthesis (Goutz et al, 1984, Tomajka, 1985). For zooplankton, direct effects of contamination may include suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation (Chamberlain and Robertson, 1999). Impacts on plankton communities are likely to occur in areas where dissolved or entrained hydrocarbon threshold concentrations are exceeded, but communities are expected to recover 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 (ie, years) population declines (ITOPF, 2011).

The submerged shoals of Rankin Bank and Glomar Shoal, Clerke and Imperious Reefs are areas associated with sporadic upwelling and associated primary productivity events. Spill model results predict entrained hydrocarbons/dissolved aromatic hydrocarbons (at or above the 500 ppb threshold) for both submerged shoal areas, therefore, impacts to plankton communities may result in short term changes in plankton community composition but recovery would occur (see offshore description above). Furthermore, there is the possibility for lower concentration exposure for dissolved hydrocarbons. Hydrocarbon contact during the spawning seasons for resident shoal community benthos and fish (meroplankton), particularly exposure to in water toxicity effects to biota, may result in the loss of a discrete cohort population but would not affect the longer term viability of resident populations.

Sharks (including whale sharks and rays)

Hydrocarbon contact may affect whale sharks as they traverse through or forage within the BIA and are exposed to hydrocarbons through direct physical coating (surface slicks) and ingestion (surface slicks and entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks aggregate annually to feed in the waters around Ningaloo Reef, from March to July with the largest numbers recorded in April and May (Sleeman et al., 2010). However seasonal aggregation can be variable, with individual whale sharks recorded at other times of the year. Whale sharks located in open ocean, offshore waters are most likely transiting and individuals that have direct contact with hydrocarbons within the spill affected area may be impacted but the consequences to migratory whale shark populations will be minor.

Impacts to sharks and rays may occur through direct contact with hydrocarbons and contaminate the tissues and internal organs either through direct contact or via the food chain (consumption of prey). In the offshore environment, it is probable that pelagic shark species are able to detect and avoid surface waters underneath oil spills by swimming into deeper water or away from the affected areas. Ray populations inhabiting seabed habitats in the deeper offshore waters are not predicted to be affected by the condensate spill.

Pelagic Fish Populations

Fish mortalities are rarely observed to occur as a result of oil spills (ITOPF, 2011). Scholz et al (1992) concluded that fish do not generally experience acute mortality due to oil spills, and that it is rare to find fish kills after a spill, especially in open water environments. This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath oil spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved hydrocarbons are capable of eliminating the toxicants exposed to uncontaminated marine waters, hence individuals exposed to a spill are likely to recover (Concawe, 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. A spill of diesel or condensate from the NRC facility is therefore unlikely to cause a major impact on short-term survival of open water pelagic fish but may result in a level of sub-lethal stress on fish. The potential impacts to fish populations in open waters are considered to be minor.

Submerged Shoals

The waters overlying the submerged Rankin Banks have the potential to be contacted by surface slicks (greater than 10 g/m^2) or exposed to entrained oil droplets (greater than 500 ppb). Similarly, Glomar Shoals has the potential to be contacted by entrained and dissolved hydrocarbons (greater than 500 ppb). These permanently submerged habitats, which represent sensitive open water benthic community receptors, extend to depths as shallow as 22 m and 18 m respectively. Given the depth of these shoals, 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. Exposure to dissolved hydrocarbon concentrations below threshold may affect meroplankton and also impact early life stages of fish and invertebrate populations associated with these submerged shoals.

Spill model results indicate potential impacts to the benthic communities of the Rankin Bank and Glomar Shoals, however, it is expected that widespread habitat loss will not occur and the consequences to resident shark and ray population (if present) will be minor.

Deepwater Benthic Communities

In the event of a major release at the seabed, the model predicted hydrocarbons droplets would be entrained by the rising gas cloud, rapidly transporting them to the sea surface As a result, the low sensitivity deepwater, benthic communities associated with the unconsolidated, soft sediment habitat of the Program Area is not expected to have widespread exposure to released hydrocarbons. A localised area, approximately 14 m diameter relating to the condensate plume at the point of release is predicted which would result in a small seabed and associated epifauna exposed to hydrocarbons.

Offshore Filter Feeders

Hydrocarbon exposure to the documented offshore, filter-feeding communities (e.g. deepwater communities of Ningaloo coast,-the Muiron Islands and Dampier Archipelago) is unlikely, given the predicted dispersion of hydrocarbons above threshold levels, that exposure at concentrations of ecological consequence would not occur at depths where these heterotrophic communities occur.

Marine Sediment Quality

In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of condensate would atomise into droplets that would be rapidly transported into the water column. 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 relating to the plume diameter of approximately 14 m diameter.

There is the potential for the reduction of marine sediment quality due to contact and adherence of entrained hydrocarbons with seabed sediments of the submerged shoals.

Physical Displacement of Fauna from Gas Plume

The effect of the physical extent of the gas plume in the environment is expected to have a limited and localised effect on identified receptors such as the physical barrier created by the gas plume which may cause the displacement of transient and/or mobile biota such as pelagic fish, megafauna species (migratory whales) and plankton. It is acknowledged that the physical extent of the plume may displace some open water species transiting the offshore waters of this area of the NWS region. The extent of the plume is relatively small in comparison to the surrounding offshore environment, however, the overall impact to the in-water biota of the deepwater environment and the marine environment in general is expected to be slight to minor.

Commercial Fisheries

Spill scenarios modelled are unlikely to cause significant direct impacts on the target species of Commonwealth and offshore State fisheries within the defined ZoCs. Further details are provided below.

- Northwest Slope Trawl and Western Deep Trawl Fisheries: Oil spill scenarios are unlikely to cause significant direct impacts on the species fished by the Northwest Slope Trawl Fishery and Western Deep Trawl Fishery. This is because these fisheries are targeting benthic species (demersal finfish and crustaceans) in greater than 200 m water depth and any in-water hydrocarbons are likely to be confined to the upper water column layers. However, a major loss of containment from the NRC facility may lead to an exclusion of fishing from the spill area for an extended period.
- Western Tuna and Billfish, Skipjack Tuna, Southern Bluefin Tuna and West Australian Mackeral Fisheries: The tuna fisheries (Western Tuna and Billfish, Skipjack Tuna, Southern Bluefin Tuna fisheries (for which limited fishing activity has occurred in this area in recent years) and the Western Australian Mackerel fishery target pelagic fish species. Adult fish are highly mobile and able to move away from the spill affected area or avoid the surface waters, however, hydrocarbon concentrations in the upper water column (less than 10 m) could lead to potential exposure through direct absorption of hydrocarbons and indirectly by the consumption of contaminated prey (Merkel et al, 2012). Given these pelagic species are distributed over a wide geographical area, the impacts at the population or species level are considered minor in the unlikely event of a spill.
- Pilbara Trawl, Trap and Line Fisheries: Oil spill scenarios may impact on the area fished by the Pilbara Trawl, Trap and Line Fishery (Section 4). This fishery uses a range of gear types (trawl, trap and line) and operates in waters between 50 and 200 m water depth. In the unlikely event of a major hydrocarbon spill, there is potential for the targeted fish species to be exposed to entrained and/or dissolved hydrocarbons in the surface water layer. However the potential for direct impact would be reduced as target species are likely avoid the surface water layer underneath oil spills. A major and continuous spill is likely to lead to exclusion of Pilbara Trawl fishers from the spill area for an extended period.
- General Fisheries Impacts: Fish exposure to oil can result in ‘tainting’ of their tissues. Even very low levels of hydrocarbons can impart a taint or ‘off’ flavour or smell in seafood. Taint is reversible through the process of depuration which removes hydrocarbons from tissues by metabolic processes, although it is dependent upon the magnitude of the oil contamination. Fish have a high capacity to metabolise these hydrocarbons while crustaceans (such as prawns) have a reduced ability (NOAA, 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential contamination of seafood can affect commercial and recreational fishing, and can impact seafood markets long after any actual risk to seafood from a spill has subsided (NOAA, 2002). A major spill would result in the establishment of 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.

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. However stakeholder consultation indicates there is limited fishing activity in the vicinity of the NRC facility.

Tourism (including Recreational Fishing) N/A.

Recreational activities (tourism/fishing) are known to take place in the offshore waters of the NWS in areas such as the Rankin Banks and Glomar Shoals, as well as Clerke and Imperieuse reefs (Rowley Shoals) despite their remote offshore location. DPAW (formerly DEC) must approve access to the Commonwealth and state protected areas of the Rowley Shoals. This is to control access and ensure the area’s management objectives are not compromised.

In the unlikely event of a major spill, a temporary prohibition on charter boat recreational fishing trips to the Rankin Bank, the Glomar Shoals, and Rowley Shoals would be put into effect.

Water Quality in open water and submerged shoals

Water quality would be affected due to hydrocarbon contamination in open waters, offshore shoals (e.g. Rankin Banks and Glomar Shoals) and reef systems such as Clerke, Imperieuse and Mermaid Reef within the ZoC which is described in terms of the biological effect concentrations. These are defined by the ZoC descriptions for each of the surface, entrained and dissolved hydrocarbon fates and their predicted extent. The surface waters overlying the submerged Rankin Bank and Glomar Shoals have the potential to be exposed to entrained hydrocarbons/dissolved aromatic hydrocarbons (at or greater than 500 ppb). The surface waters overlying the submerged

Rankin Bank and Glomar Shoals have the potential to be exposed to entrained hydrocarbons/dissolved aromatic hydrocarbons (at or greater than 500 ppb). Furthermore, water quality is predicted to have minor long term and/or significant short term hydrocarbon contamination above background and/or national/international quality standards (as defined by the Woodside Environmental consequence definitions).

Protected Areas

Reserves within the ZoC may be affected by the released hydrocarbons. Such hydrocarbon contact may alter stakeholder understanding and/or perception of the protected marine environment, given these areas represent pristine and biologically diverse offshore environments.

In the unlikely event of a major spill and entrained hydrocarbons contacting 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 and potentially include Barrow/Lowendal/Montebellos Marine Management Area, the Pilbara islands – nature reserves (Southern Island groups) and the World Heritage Area (WHA) of the Ningaloo coast and Shark Bay. A number of the offshore Commonwealth marine reserves such as Montebellos, Dampier, Gascoyne and Shark Bay may also be affected

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 within the Protected Area for a period of time and subsequent potential for economic impacts to affected commercial fishing operators. However stakeholder consultation indicates there is limited fishing activity in the vicinity of the NRC facility (Section 9).

Petroleum Activities

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 support vessel access as well as offtake tankers approaching facilities off the North West Shelf. 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 facilities are Goodwyn A facility and Angel facility operated by Woodside. Operation of these facilities is likely to be affected in the event of a well blow-out spill.

<u>Potential Impacts on Nearshore Waters, Islands and Shoreline Receptors</u>

Based on the modelling all modelled scenarios have potential for spills to contact waters adjacent to shorelines above threshold concentrations if the scenarios occurred. The model predicted:

- Surface slicks (greater than 10 g/m^2) would~~-not~~ have the potential to contact Montebello CMR, Montebello, Lowendal and Barrow[5] Islands, the Ningaloo Coast, Shark Bay[6] (Open ocean) and Shark Bay (under bay including the State Marine Park) Shoreline accumulation (greater than 100 g/m^2) has the potential to accumulate at Barrow Island, and Ningaloo Coast (south and mid) locations.
- Entrained hydrocarbons (greater than 500 ppb) at all receptors as outlined in Table 8-16 with the exception of Montebello Islands CMR ~~i~~
- Dissolved aromatic hydrocarbons (greater than 500 ppb) in the water column has the potential to contact Argo-Rowley, Gasgoyne and Abrolhos CMRs, Glomar Shoals, Montebellow, Lowendal, Barrow Island, Murion and Pilbara Southern Islands Group), Dampier Archipelago and Ningaloo Coast

Coral Reefs

The quantitative spill risk assessment and output ZoC indicate there would be potential for entrained hydrocarbon/dissolved aromatic hydrocarbons (≥500 ppb threshold concentration) to contact shallow, nearshore waters and therefore, exposure of subtidal corals associated with the fringing reefs located at a number of mainland and island locations such as the Montebello Islands, Barrow Island, Lowendal Islands, Ningaloo Coast, Shark Bay and Rowley Shoals. Potential for

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[5] No contact identified from quantitative spill risk assessment, however, have conservatively assumed contact based on contact nearby Barrow Island.

[6] Surface contact identified with Shark Bay from quantitative spill risk assessment. Modelling did not distinguish open ocean or inner bay, therefore, it has been conservatively assumed that both would be contacted.

these reefs to be exposed to dissolved aromatic hydrocarbons concentrations that are considered to induce toxicity effects, particularly, for reproductive and juvenile stages of invertebrate and fish species dependency the reef may also occur.

Modelling of hydrocarbon spill scenarios indicated there is exposure of Ningaloo Coast to dissolved aromatic hydrocarbons above the threshold concentration. Exposure to water soluble hydrocarbon fractions via direct contact with hydrocarbon droplets can cause coral mortality in sensitive coral species (such as branching corals) (Shigenaka, 2001, NOAA 2010a), however, the potential for toxicity effects on direct contact with entrained oil will likely be reduced by weathering processes which will serve to lower the content of soluble aromatic components before contact occurs.

Exposure to entrained hydrocarbons (greater than 500 ppb) has potential to result in lethal or sublethal toxic effects to corals and other sensitive sessile benthos within the upper ten metres of the 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, resulting in the reduction in coral cover and change in the composition of coral communities where threshold concentrations are exceeded. Sublethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in growth rates and impaired reproduction (Negri and Heyward, 2000). With reference to Ningaloo Reef, wave-induced water circulation that flushes the lagoon may promote removal of entrained oil from the lagoon. Under typical conditions, breaking waves on the reef crest cause a rise in water level in the lagoon creating a pressure gradient that drives water out in a strong outward flow through channels. These channels incise the reef across as much as 15% of the length of Ningaloo Reef (Lowe et al, 2008, Taylor and Pearce, 1999).

There would also be potential for surface hydrocarbons (≥ 10 g/m2) to reach reef habitat at highly localised areas at Ningaloo Coast. The Ningaloo Reef system includes the extremely shallow subtidal and intertidal coral communities of the reef crest and reef flat habitats, dominated by branching and tabular Acropora sp. corals. These 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. 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) (NOAA, 2010a). The duration of surface slick contact with the reef flat may be reduced as the slick will likely be lifted off the reef by the flooding tide, however exposure will be prolonged where hydrocarbons adhere. There is significant potential for lethal impacts due to the physical hydrocarbon coating of sessile benthos, 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).

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 along the Ningaloo Coast, there is potential for a reduction in successful fertilization and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons via direct contact with the entrained hydrocarbons (Negri and Heyward, 2000). Such impacts have the potential to result in the failure or reduction of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected, 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 oil exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. It is noted that entrained hydrocarbons at or above 500 ppb threshold concentration may reach reefs at a number of mainland and island locations (such as the Montebello Islands, Barrow Island, Lowendal Islands and the Ningaloo Coast). In contrast, results of the modelled scenarios indicated there was no potential for these reefs to be exposed to dissolved aromatic hydrocarbons at or above the 500 ppb threshold concentration, however, there is the potential for the reef subtidal habitats to be exposed to dissolved aromatic hydrocarbons at concentrations that are considered to induce toxicity effects, particularly, for reproductive and juvenile stages of invertebrate and fish species.

Over the worst affected sections of a reef, coral community live cover, structure and composition may potentially be reduced, manifested by loss of corals and associated sessile biota. Oil spill impacts to a reef were recorded for the Bahia Las Minas oil spill off Panama in 1986. At heavily oiled reefs, total live coral cover decreased by up to 76% in the shallower depth range of 0.5 to 3 m and 56% in the greater than 3 to 6 m range. Furthermore, colony size and diversity also decreased significantly with oiling (Guzman et al, 1991). Recovery of these impacted reef areas will rely on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. 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. **Intertidal and Shallow Sub-tidal Shoreline Habitats (Mud Flats, Mangroves, Salt Marsh, Seagrasses and Sandy Shores)** Modelling for scenarios predicted entrained hydrocarbons at or greater than 500 ppb have the potential to contact a number of shoreline sensitive receptors such as those supporting biologically diverse, shallow subtidal and intertidal communities. Shallow, subtidal and intertidal communities at these locations comprise a variety of habitat and communities types, from the upper sublittoral to the upper intertidal zones which support a high diversity of marine life and are utilised as important foraging and nursery grounds by a number of invertebrate or vertebrate species. Depending on the trajectory of the plume of entrained hydrocarbons, macroalgal/seagrass communities including at Montebello Islands, Barrow Island, Lowendal Islands, the Southern Island Group (documented as low and patchy cover), Muiron Islands (associated with limestone pavements), Ningaloo Coast (patchy low cover associated with the shallow limestone lagoonal platforms), plus mangrove habitat and associated mud flats and salt marsh at Ningaloo Coast (small habitat areas), Dampier Archipelago, Montebello Islands, Barrow Island, Lowendal Islands and Muiron Islands have the potential to be exposed. In addition depending on the trajectory, surface slick may also contact intertidal and subtidal macroalgal/seagrass communities along Ningaloo Coast (patchy low cover associated with the shallow limestone lagoonal platforms). Entrained hydrocarbons contacting nearshore areas may adhere to the sediments, depositing to the shore or seabed, although this process is less likely for condensate (IPIECA 1992). Persistence may be limited by the small proportion of persistent residual fractions (BP >380°C) of the condensate (NWS condensate: 0.1%; Perseus condensate: 0.2%). Impacts may include sub-lethal stress and mortality to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and other invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to loss of habitats and/or lethal and sublethal 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 significant secondary impacts on shorebirds, fish, sea turtles, rays, and crustaceans that utilise these intertidal habitat areas for breeding, feeding and nursery habitat purposes. Entrained hydrocarbons reaching mangrove habitats may adhere to the sediment particles, although this process is less likely for condensate (IPIECA 1992). Oil that has incorporated into sediment has the potential to cause toxicity effects to mangrove via uptake through subsurface roots (NOAA, 2010b). In low energy environments such as in mangroves, deposited sediment-bound oil is unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (NOAA, 2010b). At wave-sheltered or wave-exposed shorelines, the potential for chronic sublethal toxicity impacts beyond immediate acute effects (which may delay recovery in an affected area), may be reduced as condensate comprises a very small proportion (NWS condensate: 0.1%; Perseus condensate: 0.2%) of persistent residual fractions (BP >380°C). Seagrass beds occurring in the intertidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues of seagrass (Runcie *et al*., 2004). The potential for toxicity effects of entrained oil will likely be reduced by weathering processes which will serve to lower the content of soluble aromatic components before contact occurs. Exposure to entrained/dissolved hydrocarbons may result in seagrass mortality, depending on actual entrained/dissolved 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 communities are likely to occur in areas where hydrocarbon threshold concentrations are exceeded Seagrass beds occurring in the intertidal zone may be susceptible to impacts from entrained hydrocarbons Entrained oil reaching seagrass beds has potential to induce toxicity effects due to absorption of soluble fractions of oil into tissues (Runcie et al, 2004). The potential for toxicity effects of entrained oil will likely be reduced by weathering processes which will serve to lower the content of soluble aromatic components before contact occurs. Exposure to entrained hydrocarbons may result in seagrass mortality, depending on actual entrained hydrocarbon concentration received and duration of exposure. The potential for toxicity effects on direct contact with entrained oil will likely be reduced by weathering processes which will serve to lower the content of soluble aromatic components before contact occurs. Sub-lethal stress effects due to physical contact with entrained droplets may include reduced growth rates and a reduction in tolerance to other stress factors (Zieman et al, 1984). Impacts on seagrass communities are likely to be seen in areas where hydrocarbon threshold concentrations are exceeded. **Marine Sediment Quality**

Entrained hydrocarbons (at or above the ecological threshold) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines (refer to **Table 6-18**) and surface slicks (at or above the ecological threshold) may occur for the Ningaloo Middle coast. Such hydrocarbon contact may lead to reduced marine sediment quality by several processes such as: adherence to sediment and deposition shores or seabed habitat, although these processes are less likely for condensate (IPIECA, 1992). Surface slicks predicted to potentially contact areas of the Ningaloo Coast also have the potential to reduce sediment quality due to minor long term or significant short term hydrocarbon contamination above background and/or national/international quality standards.

Water Quality

Water quality would be affected/reduced due to hydrocarbon contamination with modelling predictions indicating that hydrocarbon contact is at or above biological effect concentrations for entrained hydrocarbons in nearshore waters of identified islands and the mainland coast. Such reduction in water quality is predicted to have minor long term or significant short term hydrocarbon contamination above background and/or national/international quality standards.

Marine Megafauna – Marine Mammals

In addition to a number of whale species that may occur in nearshore waters, coastal populations of small cetaceans and dugongs are known to reside or frequent nearshore waters, including the Dampier Archipelago, Ningaloo Coast, Exmouth Gulf and Muiron Islands.

Marine mammals are mobile and may detect and avoid surface slicks to a certain extent. The potential impacts of exposure are as discussed previously (Section 6.7.9.2). In the nearshore, additional potential environment impacts may also include the potential for dugongs to ingest hydrocarbons when feeding on contaminated seagrass stands, or indirect impacts to dugongs if loss of this food source occurred due to dieback in worse affected areas. However, the potential for impact to dugongs due to any reduction in seagrass abundance or quality may be reduced by their natural migratory behaviour to move to and forage in unaffected areas.

Marine Megafauna – Seabirds and Shorebirds

In the unlikely event of a major spill, there is potential for shoreline habitats (beaches, mudlflats and reef flat) and nearshore waters that seabirds and resident and non-breeding overwintering shorebirds utilise for foraging and resting to be exposed to entrained hydrocarbons. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds will 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 resulting in particularly sensitivity of these areas in the event of a spill.

The pathway of biological exposure that can result in lethal and sublethal impacts of hydrocarbons is exposure via indirect consumption of contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can lead to internal injury to sensitive membranes and organs (IPIECA, 2004; AMSA, 2012). Shorebirds that confine feeding to shorelines are likely to be less susceptible to severe hydrocarbon contamination compared to seabirds that fully immerse during feeding. Matting of feathers on heavily oiled birds may lead to hypothermia, starvation due loss of ability to fly and forage, and drowning due to loss of buoyancy. Oiled birds may ingest hydrocarbons directly when preening or indirectly by consuming contaminated fish (nearshore waters) or invertebrates (oiled intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion and oiling can also lead to internal injury to sensitive membranes and organs (IPIECA, 2004; AMSA, 2012). Whether the toxicity of ingested hydrocarbons is lethal or sublethal will depend on the weathering stage and its inherent toxicity. Exposure to hydrocarbons may have longer term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks, affecting survivorship and loss of adult birds.

Marine Megafauna – Marine Reptiles

Several marine turtle species utilise nearshore waters and shorelines for foraging and breeding in potentially impacted locations such as the Montebello Islands, Barrow Island, Serrurier Island (Pilbara Islands, Southern Island Group), Lowendal Islands and Dampier Archipelagom Ningaloo Coast (north), Muiron Islands, Serrurier Island (Southern Island Group) and Dirk Hartog Island (Shark Bay) (Section 4), which could be exposed to entrained hydrocarbon above the 500 ppb threshold concentration. During the breeding season, turtle aggregations near nesting beaches will be most vulnerable due to greater turtle densities. As discussed previously, turtles are vulnerable to lethal and sublethal effects due to ingestion of hydrocarbons. In the nearshore environment, turtles can ingest hydrocarbons when feeding on contaminated seagrass stands or can be indirectly affected by loss of seagrass due to dieback (Gagnon and Rawson, 2010).), though given the nature of the condensate spill and that shoreline accumulation of hydrocarbons at or above concentrations of ecological consequence is not predicted.

The reproductive success of nesting turtles can be reduced where eggs are exposed to hydrocarbons as a result of the transfer of hydrocarbons from oiled female turtles during egg laying (NOAA, 2010a). Oiling of gravid adult females or hatchlings will have the potential to occur in nearshore waters or whilst traversing beaches where surface and entrained hydrocarbons are expected to make shoreline contact. Weathered hydrocarbons have been shown to have little impact on egg survival, while fresh oil significantly reduced egg survival (Milton and Lutz, 2002). Given turtles nest above the highwater mark, buried eggs are unlikely to be directly exposed to any hydrocarbons percolating through the sand (NOAA, 2010c). Given turtles nest above the highwater mark, buried eggs are unlikely to be directly exposed to any hydrocarbons percolating through the sand (NOAA, 2010c). During the breeding season, turtle aggregations near nesting beaches will be most vulnerable due to greater turtle densities and potential for entrained hydrocarbon exposure in the nearshore waters. Exposure to entrained hydrocarbons above threshold concentrations to turtle adults and hatchlings may lead to sublethal stress and irritation, though the potential for impact may be reduced in nearshore waters due to weathering processes which will serve to lower the content of soluble aromatic components before entrained oil reaches these locations. Given surface slicks above threshold concentrations are not predicted to shorelines, significant physical oiling of gravid adult females or hatchlings or physical transfer of oil to eggs on beaches is not expected to occur.

Impacts to sea snakes for the mainland and island nearshore waters from direct contact with hydrocarbons may occur, and may include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (ITOPF, 2011).

Marine Megafauna – Sharks (including whale sharks) and rays

Whale sharks and manta rays, known to frequent the Ningaloo Reef system (and form feeding aggregations in late summer/autumn within the Whale Shark BIA) are vulnerable to entrained hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large amounts of water over their gills to catch planktonic and nektonic organisms (Jarman and Wilson, 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive sub-surface ram-feeding and active surface feeding (Taylor, 2007). Passive feeding consists of swimming slowly at the surface with the mouth wide open. During active feeding sharks swim high in the water with the upper part of the body above the surface with the mouth partially open (Taylor, 2007). These feeding methods would result in potential for individuals that are present in worse affected areas to ingest potentially toxic amounts of entrained hydrocarbons. 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 hydrocarbons through the contamination of their prey. The preferred food of whale sharks are fish and coral eggs and phytoplankton which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If a spill event were to occur during the spawning season, this important food supply (in worse spill affected areas of the reef) may diminish or be 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 populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. Spill modelling results do indicate potential impacts to the benthic communities of nearshore, subtidal communities of islands, the Ningaloo north (mainland coast) and Shark Bay (open ocean), however, it is expected that widespread habitat loss will not occur and the consequences to resident shark and ray population (if present) will be minor.

Fish Populations

Fish (and other commercially-targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sublethal impacts from exposure to hydrocarbons, particularly if a spill coincides with the spawning season or if a spill reaches nursery areas close to the shoreline (e.g. seagrass and mangroves) (ITOPF, 2011). Fish spawning (including for commercially targeted species such as snapper and mackerel) occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a major spill there is potential for entrained concentrations to occur in the surface water layer (less than 10 m) above threshold concentrations in nearshore waters including Dampier Archipelago, Montebello Islands, Barrow Island, Lowendal Islands, Southern Island Group, the Muiron Islands and the Ningaloo Coast, Shark Bay and Abrolhos Islands. This has the potential to result in lethal and sublethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the condensate. These losses of fish larvae in worse 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).

Site attached fish (for example coral reef fish), 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 fish populations will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. It is also noted that the early life stage of resident fish populations is particularly sensitive to hydrocarbon exposure.

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 sublethal 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) (ITOPF, 2011). Fish spawning (including for commercially targeted species such as snapper and mackerel) occurs in nearshore waters at certain times of the year and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters. Modelling indicated that in the unlikely event of a major spill there is potential for entrained hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters including Montebello Islands, Barrow Island, Lowendal Islands, Southern Island Group, Dampier Archipelago, the Muiron Islands and the Ningaloo Coast (north) and Shark Bay(open ocean). This, and the potential for possible lower concentration exposure for dissolved hydrocarbons, have the potential to result in lethal and sublethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the condensate. These losses of fish larvae in worse 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).

Non Biogenic Coral Reefs

The coral communities fringing the offshore Pilbara region (e.g. the Southern Island Group) may be exposed to entrained hydrocarbons (at or above 500 ppb) and consequently exhibit lethal or sublethal 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.

Sandy Shores/ Estuaries / Tributaries / Creeks (Including Mudflats) / Rocky Shores

Shoreline accumulation of hydrocarbons is not expected at levels of ecological consequence, however, potential impacts may occur due to entrained hydrocarbon contact with shallow, subtidal and intertidal zones of the Montebello Islands, Barrow Island, Lowendal Islands, the Southern Island Group, Muiron Islands, the Ningaloo Coast and Shark Bay (open ocean). In-water toxicity of the entrained hydrocarbons reaching these shores will determine impacts to the marine organisms such as sessile barnacle species and/or mobile gastropods and crustaceans such as amphipods. Lethal and sublethal impacts may be expected where the entrained hydrocarbon concentration threshold is > 500 ppb.

Marine Sediment Quality

Entrained hydrocarbons (at or above the ecological threshold) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines (refer to **Table 6-18**) and surface slicks (at or above the ecological threshold) may occur for the Ningaloo Middle coast. Such hydrocarbon contact may lead to reduced marine sediment quality by several processes such as: adherence to sediment and deposition shores or seabed habitat, although these processes are less likely for condensate (IPIECA, 1992). Surface slicks predicted to potentially contact areas of the Ningaloo Coast also have the potential to reduce sediment quality due to minor long term or significant short term hydrocarbon contamination above background and/or national/international quality standards.

Nearshore Fisheries and Aquaculture

Pilbara Trawl, Trap and Line Fisheries: The modelling of scenarios may impact on the area fished by the Pilbara Trawl, Trap and Line Fishery (Section 4). This fishery uses a range of gear types (trawl, trap and line) and operates in waters between 50 and 200 m water depth. In the unlikely event of a major hydrocarbon spill, there is potential for the targeted fish species to be exposed to entrained and/or dissolved hydrocarbons in the surface water layer. Targeted fish, prawn, mollusc and lobster species and pearl oysters could experience sub-lethal stress, or in some instances, mortality depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. However, In the event of a major spill the modelling indicated the ZoC tends to remain offshore and not extend to nearshore waters closest to the mainland Pilbara coast, including the actively fished areas of designated Prawn Managed Fisheries and managed prawn nursery areas.

Onslow and Exmouth Prawn Managed Fishery: The modelling of scenarios indicated that fishing grounds of the Onslow Managed Fishery and Exmouth Gulf Managed Fishery are in the ZoC (included as Muiron Island receptor).

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 (Ronnback et al, 2002), whereas juvenile tiger prawns are most abundant in areas of seagrass (Masel and Smallwood, 2000). Adult prawns also inhabit coastline areas but tend to move to deeper waters to spawn. In the event of a major spill, the model predicted shallow subtidal and intertidal habitats at Montebello Islands, Barrow Island, Lowendal Islands, Pilbara Islands - Southern Island Group, Muiron Islands and mangrove and seagrass habitats of the Ningaloo Coast are located within the ZoC that 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 sublethal effects occur will depend on duration of exposure, hydrocarbon concentration and weathering stage of the oil 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

Exmouth Gulf Pearl Leases: In the unlikely event of a major spill, there is the possibility that target species in some areas utilised by a number of state fisheries, and wild oysters in the Pearl Oyster Managed Fishery that are within the ZoC could be affected.

Nearshore Fisheries and Aquaculture: In the unlikely event of a major spill, there is the possibility that target species in some areas utilised by a number of state fisheries, pearl aquaculture in nearshore waters of the Montebello Islands and wild oysters in the Pearl Oyster Managed Fishery that are within the ZoC could be affected (Section 4). Targeted fish, prawn, mollusc and lobster species and pearl oysters could experience sub-lethal stress, or in some instances, mortality depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity.

Recreational Fishing: Active recreational fishing for finfish takes place at the Dampier Archipelago, along the Ningaloo Coast and within other marine parks such as the Montebello Islands (Section 4). As discussed previously, targeted pelagic species are mobile and are unlikely to cause significant direct impacts on the target species. A major spill is unlikely to cause a major impact on short-term survival of open water pelagic fish but may result in a level of sub-lethal stress on fish.

Tourism and Recreational Use: In the unlikely event of a major spill, the nearshore waters of island groups including Barrow/Lowendal/Montebellos and the Pilbara islands (Southern Island groups) and Ningaloo coast could be reached by entrained oil, depending on prevailing wind and current conditions. As these locations offer 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 oil spill has dispersed.

Typically, an oil spill that results in a visible oil slick in coastal waters and reaching shorelines will disrupt recreational activities, particularly tourism and its supporting services. In the unlikely event of a major spill, hydrocarbons are not predicted to accumulate on shorelines (at or above a set threshold), however, there is potential for visible surface slicks (<10 g/m^2) (i.e. a rainbow sheen) to reach sensitive receptor locations, for example, offshore islands of Barrow/Lowendal/Montebellos). Such levels of hydrocarbon exposure, while not predicted to affect the ecological integrity of the receiving environment, may trigger a stakeholder response given the perception that these pristine and biodiverse environments have been contaminated as a result of the spill. This may lead to a temporary cessation of all marine-based tourism activities on the spill-affected coast and wider coastal area for a period of weeks or longer~~.~~

There is potential for stakeholder perception that this nearshore environment will be contaminated over the longer term resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of oil 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).

Protected Areas/Heritage/Shipwrecks: In the unlikely event of a major release entrained and

	dissolved hydrocarbons contact a number of identified key receptor locations that are protected areas encompassing offshore commonwealth waters, islands and mainland coastlines. The ZoC potentially includes: Barrow/Lowendal/Montebellos Marine Management Area, the Pilbara islands – nature reserves of the Southern Island group and the World Heritage Area (WHA) of the Ningaloo coast and Shark Bay. A number of the offshore Commonwealth marine reserves such as Montebellos, Dampier, Gascoyne and Shark Bay may also be affected. A total of seven historic shipwrecks were identified for the Montebello/Barrow Island area and include the two wrecks located at Trial Rocks (Montebello Islands), namely Trial and Tanami. The spill results do not predict surface slicks contacting the identified wrecks. However, 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). The only KEF within the Operational Area and wider Zoc is the 125 m ancient coastline and it is not expected to be impacted as it is at depth. **Summary of Potential Impacts** In the unlikely event of a major hydrocarbon spill from NRC, the ZoC will include the sensitive marine environments of Rankin Bank, Glomar Shoals, Montebello Islands, Lowendal Islands, Barrow Island, Dampier Archipelago, Muiron Islands, Ningaloo Coast (and reef system), Southern Island Group off Onslow (including Serrurier and Thevenard Islands), Shark Bay (including the outer bay and islands of Dirk Hartog, Bernier and Dorre Islands). The ZoC also includes Commonwealth Marine Reserves in offshore waters and any sensitive receptors including the open water environment amongst the identified island and mainland shoreline sensitive receptors (details of these receptors are outlined in **Section 4**). **Table 12-10** presents to the full extent of the ZoC and the sensitive receptors and their locations exposed to hydrocarbons (surface, accumulated, entrained and dissolved) at or above the set threshold concentrations.

Summary of Control Measures

The design and construction of wells is detailed in a Well Operation Management Plan (WOMP) that is assessed and accepted by NOPSEMA under the *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011*. Woodside's acceptance of well design and construction is detailed in Woodside Procedure Well Acceptance Criteria (Woodside Doc. DC0000PD7561721).

The WOMP describes the Well Lifecycle Management Process and divides the well construction process into six phases of activity, from the basis of well design to final abandonment. As part of the design, construction and abandonment, Woodside uses a range of industry standard well barrier equipment, materials and procedures to ensure all permeable zones penetrated by a well bore, with the potential to contain hydrocarbons or over-pressured water, are isolated from the surface environment during all phases of the well construction and abandonment. There are a range of procedures/assurance processes in place to test the integrity of barriers, prior to use/installation, during use/installation and post installation, as required.

All production wells are provided with SCSSSV located approximately 100 m below the seabed which activate under a variety of pre-defined scenarios, or on manual activation, to shut-in the well and isolate the reservoir from that wellhead. The wells, subsea system and facility utilise corrosion resistant materials and chemical additives as per design to protect against integrity threats (e.g. corrosion, impact, erosion, low temperature embrittlement etc). Wellhead valve design and configuration allows safe operation and control of the well (open water trees).

- Codes and Standards - Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance:
    - Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies.
    - Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea.
    - ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems.
    - ESD System (F06) - ESD systems will shut down plant and equipment.
    - Reservoir Isolation (F07) - Reservoir isolation valves will isolate the reservoir from the facility.
    - Wells (P10) - All primary and secondary barriers within the wells will isolate hydrocarbons from the reservoir.

  - Sand Management Systems (P28) - Acoustic sand detectors will ensure the integrity of pressure equipment is not compromised by the presence of sand.
  - Depressurisation (Blowdown) (F09) - Critical blowdown valves will safely depressurise inventories to avoid, or prevent the escalation of a loss of containment.
  - Substructures (P21) – Structural integrity of substructures will be maintained to ensure availability of critical systems during major accident or environment event.
- Also refer to oil spill preparedness and response performance objectives, standards and measurement criteria.
- Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

Table 12-10: Summary of receptors located in ZoC for an 11 week blowout scenario

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Operating Standard)																													Hydrocarbon contact and fate (Condensate)			
		Water & Sediment Qualtiy		Marine Primary Producers			Other habitats / Communities								Protected Species									Other Species		Socio-economic								
		Openwater – water quality (pristine)	Marine Sediment Quality (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Openwater - Productivity / upwelling	Spawning / nursery areas	Non biogenic coral reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks /lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Whale sharks	Seasnakes	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism (including recreational fishing)	Protected Areas / Heritage / Shipwrecks	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10g/m²)	Accumulated hydrocarbon (≥100g/m²)	Entrained hydrocarbon (≥500ppb)	Dissolved hydrocarbon (≥500ppb)
Offshore	Commonwealth waters	✓	✓				✓								✓	✓					✓	✓	✓	✓		✓		✓		✓	✓	x	✓	✓
	Argo Rowley CMR	✓	✓				✓								✓	✓			✓			✓	✓	✓		✓			✓		x	x	✓	✓
	Montebello CMR	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓*		✓	x	x	x
	Gascoyne CMR	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	x	x	✓	✓*
	Abrolhos CMR	✓	✓				✓								✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓			x	x	✓*	✓*
Oceanic Reefs	Mermaid Reef CMR	✓	✓	✓			✓	✓		✓		✓			✓	✓			✓		✓	✓		✓	✓			✓	✓*		x	x	✓	x
	Clerke Reef, Rowley Shoals Marine Park	✓	✓	✓			✓	✓		✓		✓			✓	✓			✓		✓	✓	✓	✓	✓			✓	✓*		x	x	✓	x
	Imperieuse Reef, Rowley Shoals Marine Park	✓	✓	✓			✓	✓		✓		✓			✓	✓			✓		✓	✓	✓	✓	✓			✓	✓*		x	x	✓	x
Submer ged Shoals	Rankin Bank	✓	✓	✓			✓	✓		✓						✓					✓	✓		✓	✓	✓		✓			x	x	✓	x
	Glomar Shoals	✓	✓	✓			✓	✓		✓						✓					✓	✓		✓	✓	✓		✓			x	x	✓	✓
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓**	x	✓	✓
	Lowendal Islands (including State Nature Reserve)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓**	x	✓	✓
	Barrow Island (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓			✓	✓		x	x	✓	✓

	Pilbara Islands - Southern Island Group (Serrurier, Thevenard & Bessieres Islands – State Nature Reserves)	✓	✓		✓			✓	✓			✓		✓		✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	✓
	Abrolhos Islands (including the State Reserve)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	x
Mainland (nearshore waters)	Dampier Archipelago	✓	✓	✓	✓	✓		✓				✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓				✓	✓
	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, Ningaloo Commonwealth Marine Reserve, State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
	Shark Bay – Open ocean (Commonwealth Marine Reserve and WHA)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓***	x	✓	x
	Shark Bay (inner bay and including the State Marine Park)	✓	✓	✓	✓	✓		✓				✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓***	x	✓	x

Inferred contact based on quantitative spill risk assessment results for nearby receptors.

** No contact identified from quantitative spill risk assessment, however, have conservatively assumed contact based on contact with near by Barrow Island.

*** Surface contact identified with Shark Bay from quantitative spill risk assessment. Modelling did not distinguish open ocean or inner bay, therefore, it has been conservatively assumed that both would be contacted.

A- 23 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by a Subsea Loss of Containment

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Pipeline and Riser System • Subsea Infrastructure • Subsea Inspection, Maintenance and Repair Activities • Major Projects.	X	X	X	X	X	X		X	X	B	1	High

Description of Source of Risk

The release of hydrocarbons as a result of a subsea loss of containment is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons conveyed in the NRC platform subsea equipment (e.g. trunkline, flowline or riser).

A decision type 'B' has been applied to this risk under the *UKOOA 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 including the bowtie methodology and oil 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 potential consequence related to this event is the release of hydrocarbons in the form of condensate and gas to the environment. To assess the potential consequences, worst credible hydrocarbon release scenarios from a subsea loss of containment were assessed. As a result, a worst case credible hydrocarbon release scenario has been defined as the rupture of one of the subsea hydrocarbon export trunklines (1TL Trunkline), which holds the largest inventory of hydrocarbons within the NRC subsea system. This could result in a release to the environment of up to 6,500 m^3 of condensate and associated gas. This scenario is based on an instantaneous large borehole release (such as major rupture or failure of the trunkline), and assumes that the entire inventory of the flowline is released plus a 10 second delay to actuation of the emergency shutdown systems (ESD), limiting further release of hydrocarbons from the wells.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality **Marine Sediment Quality** **Air Quality** **Marine Primary Producers** **Other Habitats & Communities** **Protected Species** **Socio-economic** **Protected Areas**	This section discusses the outcomes of oil spill trajectory modelling undertaken for a subsea loss of containment as a result of trunkline rupture (release of 6,500 m^3 of NWS condensate) (APASA, 2013). It defines the furthest (i.e. worst case) possible extent from the release location that could be reached by condensate at or above a particular threshold if the spill scenario occurred. **Quantitative Spill Risk Assessment – Subsea Loss of Containment** This scenario has been modelled based on the following assumptions: • **Oil type:** NWS condensate; • **Spilled condensate volume:** 6,500 m^3; • **Gas release volume:** 9,300,000 sm^3; • **Spill duration:** 4 hours; • **Depth:** 58.5 m; and • **Location:** 116° 32' 13.19" E, 20° 02'52.99" S (1TL trunkline at mid point between shore and facility).

Trajectory and Fate

The fate and trajectory of a NWS condensate spill at the seabed from a flowline rupture has been modelled using the assumptions presented in **Table 12-11** (APASA, 2013).

Table 12-11: Assumed inputs and calculated outputs, by OILMAP-Deep model for the subsea loss of containment

	Variable	NWS Condensate
Assumed discharge	Release Depth (m)	58.5
	Oil Density (g/cm^3)	0.785
	Oil Viscosity (cP)	0.560
	Oil temp (C°)	25
	Gas:oil ratio (sm^3/sm^3)	142.61
	Oil flow volume (m^3)	6,500
	Diameter of exit hole (m)	1.016

Based on Delvigne and Sweeny (1988), the pressurised discharge of oil and gas at the seabed (depth of 58.5 m) would atomise oil into droplets ranging 5 to 200 µm with 90% ranging from 75 to 150 µm. The droplets would be carried rapidly upwards by a gas plume to the sea surface. The droplets will be mixed by turbulence generated by the lateral displacement of the rising water. The larger droplets may readily surface while the smaller droplets may remain readily entrained within the wave-mixed layer of the water column (3 to 10 m depth) depending on prevailing metocean conditions.

In terms of the weathering characteristics of NWS condensate at the sea surface, assay results indicate that approximately 95.2% will be subject to relatively rapid evaporation with approximately 99% in total available to evaporate over time. Approximately 0.1% of the oil is shown to be persistent, and the overall aromatic content is approximately 10% (**Table 12-12).**

Table 12-12: Characteristics of NWS condensate

Oil type	Initial density (kg/m^3)	Viscosity (cP)	Component	Volatiles (%)	Semi-volatiles (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			BP (°C)	<180 C4 to C10	180-265 C11 to C15	265 – 380 C16 to C20	> 380 > C20	Whole
NWS condensate	0.785 at 15 °C	0.560 at 20 °C	% of total	61.3	33.9	4.7	0.1	10.32

A series of weathering tests were modelled to illustrate the potential behaviour of NWS condensate when exposed to idealised and representative environmental conditions. Two mass balance figures (**Figure 12-4**, **Figure 12-5**) illustrate the proportional fate of oil during these modelled weathering tests.

The first weathering case involved a short period release (1 hour discharge) of 50 m^3, subject to light wind conditions (constant 5 knots). In this case, the model predicted little or no entrainment of oil, 90% of mass evaporated and approximately less than 1% decayed after 24 hours. After 7 days, the model predicted approximately 6% of condensate remained as floating oil.

In the second weathering case, also a short period release (1 hour discharge) of 50 m^3 but with variable wind conditions (winds 4 to 19 knots), the model predicted entrainment of 5% of oil within 24 hours and the same rate of evaporation and decay rate as the first weathering case. In this simulation, approximately 92% of the condensate would be lost by weathering over a 7 day period (approximately 90% by evaporation and 2% due to decay). At the end of the 7 day simulation, none of the oil mass would remain as floating oil and 8% would remain as entrained oil.

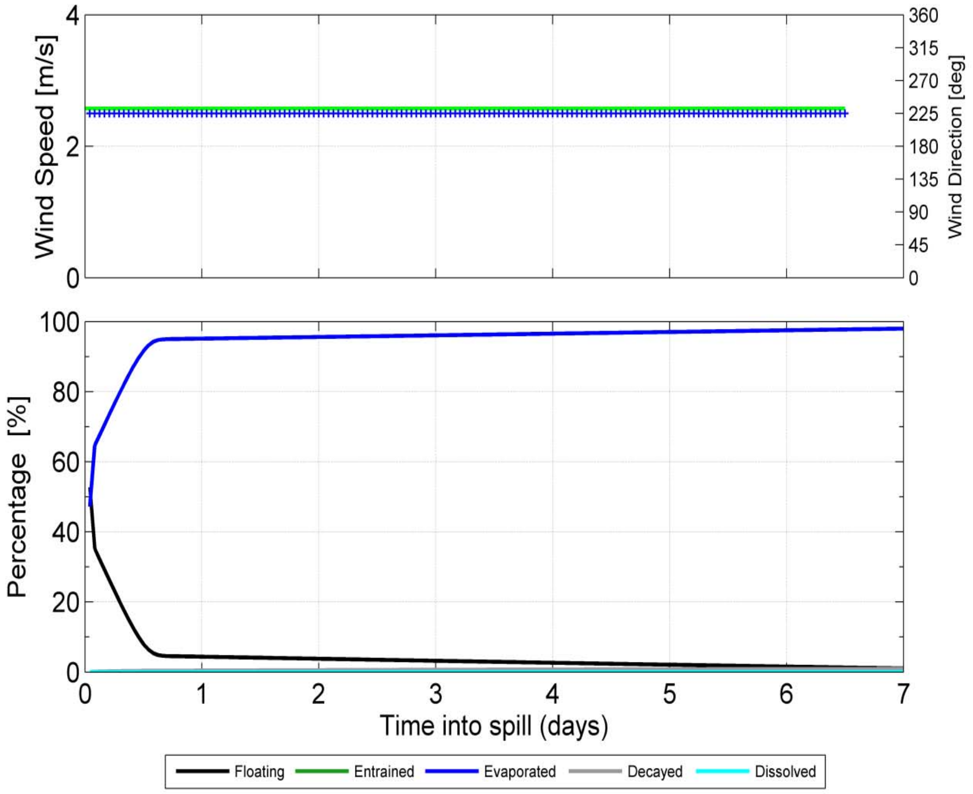

Figure 12-4: Predictions for the partitioning of oil mass over time through weathering processes for 50 m^3 of oil over a one hour surface spill of NWS condensate, as a percentage of the total mass released (predictions are based on constant 5 knot wind at 27°C water temperature and 25°C air temperature)

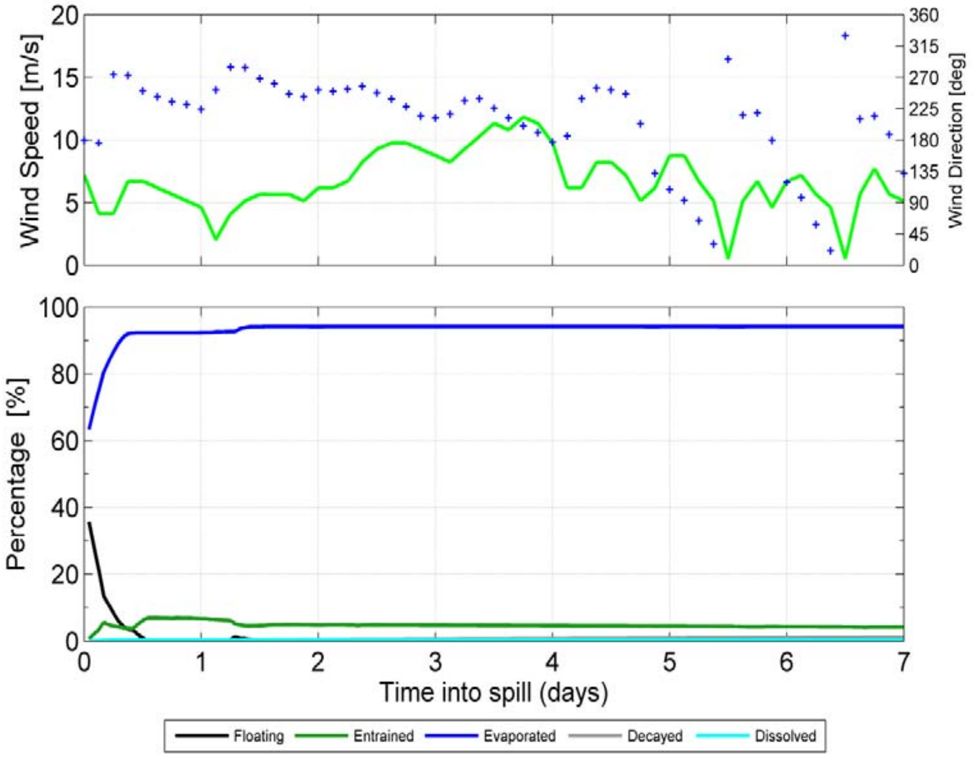

Figure 12-5: Predictions for the partitioning of oil mass over time through weathering processes for 50 m^3 of oil over a one hour surface spill of NWS condensate, as a percentage of the total mass released (predictions are based on an example of time-varying 4 to 19 knot wind at 27°C water temperature and 25°C air temperature)

Zones of Consequence

- **Surface Oil:** In the event this scenario occurred, the modelling predicted isolated instances of slicks exceeding the 10 g/m^2 threshold concentration would be confined to offshore areas up to approximately 80 km away. The sensitive locations within the ZoC for surface hydrocarbons are listed in **Table 12-13**, together with summary information on key sensitivities at each location and their distance from the modelled release location.
- **Accumulated Hydrocarbons:** Oil spill modelling results did not show hydrocarbons to accumulate (≥100 g/m^2) at any shoreline receptor, although if a spill were to occur closer to the state water boundary there is the potential for accumulation at Dampier Archipelago.
- **Entrained Oil:** In the event this scenario occurred, a plume of entrained hydrocarbons would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of entrained hydrocarbon concentrations above the 500 ppb threshold concentration are mainly offshore areas up to 530 km away with potential to contact with the Barrow Island, the Ningaloo Coast (depending on the prevailing wind and current conditions). The sensitive locations within the ZoC for entrained oil are listed in **Table 12-13**, together with summary information on key receptor sensitivities at each location and their distance from the modelled release location.
- **Dissolved Aromatics:** In the event this scenario occurred, a plume of dissolved aromatics would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of entrained hydrocarbon concentrations above the 500 ppb threshold concentration would be confined to offshore areas up to 38 km away. The sensitive locations within the ZoC for dissolved aromatics are listed in **Table 12-13**, together with summary information on key sensitivities at each location and their distance from the modelled release location.

Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release. **Table 12-13** presents to the full extent of the ZoC and the sensitive receptors and their locations exposed to hydrocarbons (surface, accumulated, entrained and dissolved) at or above the set threshold concentrations.

Summary of Control Measures

- Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance:
  - Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies.
  - Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea.
  - ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems.
  - ESD System (F06) - ESD systems will shut down plant and equipment.
  - Reservoir Isolation (F07) - Reservoir isolation valves will isolate the reservoir from the facility.
  - SSIV System (F08) – Subsea isolation valves will isolate the inventory in the pipeline from the riser and topsides affecting the riser.
  - Pipeline Systems (P09) – Pipeline and riser system will contain associated liquids and gases.
  - Chemical Injection Systems (P29) – Corrosion inhibitor injection systems will prevent internal damage to equipment is not compromised by the presence of sand.
  - Sand Management Systems (P28) - Acoustic sand detectors will ensure the integrity of pressure equipment is not compromised by the presence of sand.
- Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

Table 12-13: Summary of receptors located in ZoC for subsea loss of containment scenario

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Operating Standard)																												Hydrocarbon contact and fate (Condensate)			
		Water & Sediment Qualtiy		Marine Primary Producers			Other habitats / Communities								Protected Species									Other Species		Socio-economic								
		Openwater – water quality (prisitine)	Marine Sediment Quality (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Openwater - Productivity / upwelling	Spawning / nursery areas	Non biogenic coral reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks /lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceaans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Whale sharks	Seasnakes	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism (including recreational fishing)	Protected Areas / Heritage / Shipwrecks	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10g/m²)	Accumulated hydrocarbon (≥10g/m²)	Entrained hydrocarbon (≥500ppb)	Dissolved hydrocarbon (≥500ppb)
Offshore	Commonwealth waters	✓	✓				✓								✓	✓					✓	✓	✓	✓		✓		✓		✓	✓	x	✓	✓
	Argo Rowley CMR	✓	✓				✓								✓	✓			✓			✓	✓	✓		✓			✓		x	x	✓	X
	Dampier CMR	✓	✓				✓			✓					✓	✓			✓		✓	✓	✓	✓	✓	✓			✓		✓[1]	✓[1]	✓	✓[1]
	Montebello CMR	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	x
	Gascoyne CMR	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	x	x	✓	x
Subm erged Shoals	Rankin Bank	✓	✓	✓			✓	✓		✓						✓					✓	✓		✓	✓	✓		✓			x	x	✓	x
	Glomar Shoals	✓	✓	✓			✓	✓		✓						✓					✓	✓		✓	✓	✓		✓			x	x	✓	x
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	x
	Lowendal Islands (including State Nature Reserve)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	x
	Barrow Island (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	x	x	✓	x
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		x	x	✓	x
	Pilbara Islands - Southern Island Group (Serrurier, Thevenard & Bessieres Islands – State Nature Reserves)	✓	✓		✓			✓	✓			✓		✓		✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		x	x	✓	x

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Operating Standard)																													Hydrocarbon contact and fate (Condensate)			
		Water & Sediment Qualtiy		Marine Primary Producers			Other habitats / Communities								Protected Species									Other Species		Socio-economic								
		Openwater – water quality (prisitine)	Marine Sediment Quality (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Openwater - Productivity / upwelling	Spawning / nursery areas	Non biogenic coral reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks /lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Whale sharks	Seasnakes	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism (including recreational fishing)	Protected Areas / Heritage / Shipwrecks	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10g/m^2)	Accumulated hydrocarbon (≥10g/m^2)	Entrained hydrocarbon (≥500ppb)	Dissolved hydrocarbon (≥500ppb)
Mainland (nearshore waters)	Dampier Archipelago	✓	✓	✓	✓	✓		✓				✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓[1]	✓[1]	✓	✓[1]
	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, Ningaloo Commonwealth Marine Reserve, State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		X	x	✓	X

1 - Within ZoC if spill location moved to boundary of Commonwealth / State Waters

A- 24 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by a Topsides Loss of Containment

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Topsides • Process Description • Facility Operations • Hydrocarbon Inventories	X	X	X	X	X	X		X	X	C	1	Medium

Description of Source of Risk
The release of hydrocarbons as a result of topsides loss of containment is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons in the NRC topsides equipment. A Topside Loss of Containment could be caused by extreme environmental conditions, corrosion, erosion, a welding defect, piping/equipment repair defect, vibration, fatigue, failure and equipment overpressure. It could also be the result of loss of structural integrity, loss of marine vessel separation and loss of control of suspended load. A loss of containment from the topsides process equipment includes all high pressure gas equipment and piping manifolds and non-process hydrocarbon and chemical inventories. The scope of this MEE includes hydrocarbon inventories that could be released to the environment from: • Process gas releases; • Process condensate releases; and • Non-process hydrocarbon and chemical inventory releases. A decision type 'B' has been applied to this risk under the *UKOOA 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 including the bowtie methodology and oil spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability through peer review, benchmarking and stakeholder consultation. The potential consequence related to this event is the release of hydrocarbons in the form of condensate, diesel and gas to the environment. To assess the potential consequences, worst credible hydrocarbon release scenarios from a topside process and non-process release have been defined. The worst credible loss of containment for each scenario is based on the largest isolatable hydrocarbon inventory. **Spill Volumes:** For a non-process release, the worst credible scenario is defined as the loss of the entire inventory of the topside diesel storage tank, which holds a maximum inventory of 440 m3 of diesel. This scenario is based on a large borehole release (such as major rupture or failure) where the entire inventory would be released in less than 10 minutes, and assumes the maximum inventory of a tank is released. For a process release, the worst credible scenario is the loss of the usual inventory of condensate in the Separation System (Train 100 – 300) which is 78 m3.

Potential Environmental Impacts	
Value	**Description of Potential Environmental Impact**
Water Quality **Air Quality** **Marine Primary Producers** **Other Habitats & Communities** **Protected**	This section discusses the outcomes of oil spill trajectory modelling undertaken for a hydrocarbon release from both a topside process release (condensate – as conducted at the GWA Facility located 25 km from NRC) and a topside non-process release (diesel – as conducted for the GWF Operational Area (located 11km to the south west of the NRC facility)) (APASA, 2012). The previous modelling of a 276 m^3 topsides condensate release at the GWA Facility was considered to be a conservative representation of a 78 m^3 topsides condensate release at NRC given the similarity of the release volume and spill location. In the same way, the previous

Species
Socio-economic
Protected Areas

modelling of 10 a minute, 500 m^3 topsides release of diesel at GWF was considered representative of a topsides diesel release at the NRC.

The section focuses on the defining the furthest (i.e. worst case) possible extent from the release location that could be reached by hydrocarbons at or above a particular threshold if the spill scenario occurred.

Quantitative Spill Risk Assessment – Topside Process Release (Condensate)

This scenario has been modelled based on the following assumptions:

- **Oil type:** NWS Condensate;
- **Spilled volume:** 276 m^3;
- **Spill duration:** 10 minutes;
- **Depth:** Surface; and
- **Location:** 115.930° E, 21.652° S (GWA Platform).

Trajectory and Fate

The fate and trajectory of a condensate spill at the sea surface from a loss of containment has been modelled at GWA facility location, which is located approximately 25 km to the south west of the NRC facility (APASA, 2012).The condensate release would spread out across the sea surface and form a slick drifting with the prevailing current. A series of weathering tests were modelled to illustrate the potential behaviour of NWS condensate when exposed to idealised and representative environmental conditions. Two mass balance figures (**Figure 12-6**, **Figure 12-7**) illustrate the proportional fate of hydrocarbons during these modelled weathering tests.

The first weathering case involved a short period release (1 hour discharge) of 50 m^3, subject to light wind conditions (constant 5 knots). In this case, the model predicted little or no entrainment of hydrocarbons, 90% of mass evaporated and approximately less than 1% decayed after 24 hours. After 7 days, the model predicted approximately 6% of the condensate remained as floating oil.

In the second weathering case, also a short period release (1 hour discharge) of 50 m^3 but with variable wind conditions (winds 4 to 19 knots), the model predicted entrainment of 5% of hydrocarbons within 24 hours and the same rate of evaporation and decay rate as the first weathering case. In this simulation, approximately 92% of the condensate would be lost by weathering over a 7 day period (approximately 90% by evaporation and 2% due to decay). At the end of the 7 day simulation, none of the condensate mass would remain as floating hydrocarbons and 8% would remain as entrained hydrocarbons.

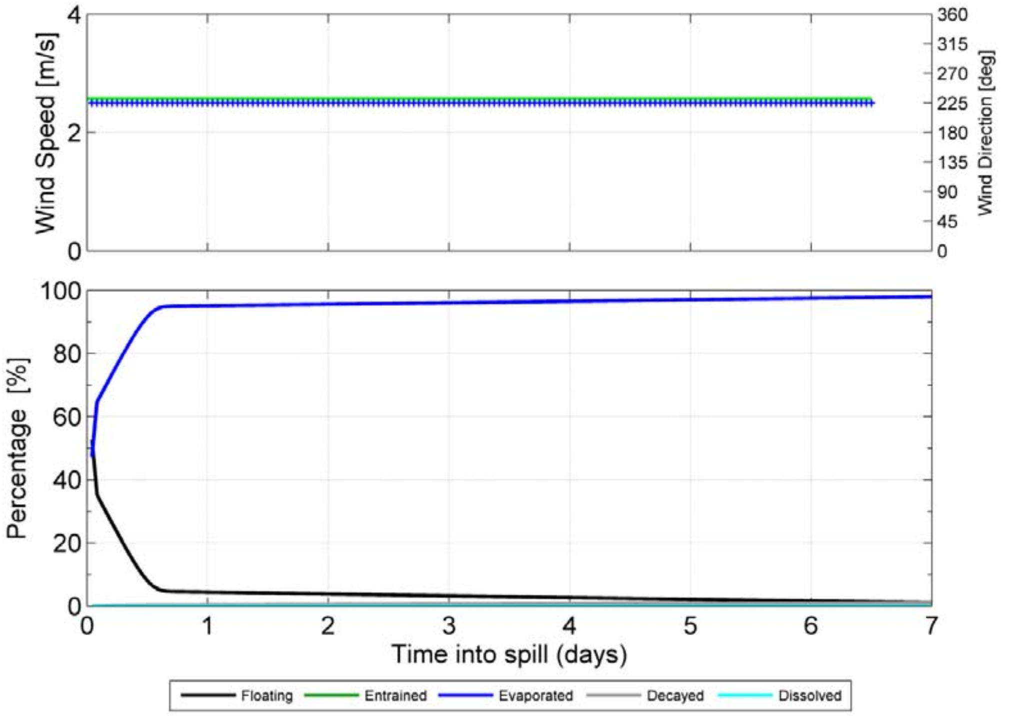

Figure 12-6: Predictions for the partitioning of oil mass over time through weathering processes for 50 m^3 of oil over a one hour surface spill of NWS

condensate, as a percentage of the total mass released (predictions are based on constant 5 knot wind at 27°C water temperature and 25°C air temperature)

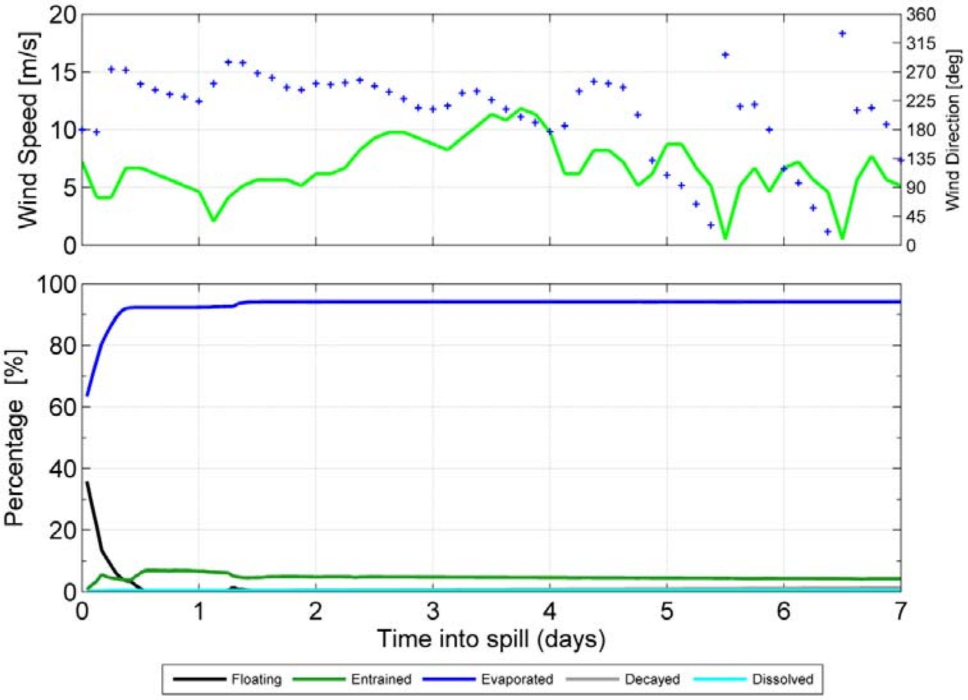

Figure 12-7: Predictions for the partitioning of oil mass over time through weathering processes for 50 m^3 of oil over a one hour surface spill of NWS condensate, as a percentage of the total mass released (predictions are based on an example of time-varying 4 to 19 knot wind at 27°C water temperature and 25°C air temperature)

Zone of Consequence

Surface Oil: In the event this scenario occurred, a surface slick would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of surface oil concentrations above the 10 g/m^2 threshold concentration would be confined to offshore areas up to 85 km away. The sensitive locations within the ZoC for floating surface oil are listed in Table 12-14, together with summary information on key sensitivities at each location and their distance from the facility.

Accumulated Hydrocarbons: Oil spill modelling results did not show hydrocarbons to accumulate (≥100 g/m^2) at any shoreline receptor.

Entrained Oil: In the event this scenario occurred, a plume of entrained oil would form down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of entrained oil concentrations above the 500 ppb threshold concentration are confined to offshore areas up to approximately 12 km away. The sensitive locations within the ZoC for entrained oil are listed in **Table 12-14**, together with summary information on key sensitivities at each location and their distance from the facility.

Dissolved Aromatics: Oil spill modelling predicted dissolved aromatic hydrocarbon concentrations remain well below 500 ppb. There were no predicted instances where the 500 ppb threshold concentration was exceeded. This finding is reflected in Table 12-14 and no plots are provided for this result.

Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release. Table **12-14** presents to the full extent of the ZoC and the sensitive receptors and their locations exposed to hydrocarbons (surface, accumulated, entrained and dissolved) at or above the set threshold concentrations.

Summary of Control Measures

- Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance:

  - Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies.
  - Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea.
  - Fire and Gas Detection (F01) - Fire and gas detection systems will facilitate prevention and response to fire or gas hazards.
  - ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems.
  - ESD System (F06) - ESD systems will shut down plant and equipment.
  - SSIV System (F08) – Subsea isolation valves will isolate the inventory in the pipeline from the riser and topsides affecting the riser.
  - Depressurisation (Blowdown) (F09) - Critical BDV will safely depressurise inventories to avoid, or prevent the escalation of a loss of containment.
  - Relief Systems (F21) – Relief systems will protect pressurised equipment, equipment exposed to high pressures and piping from a loss of containment.
  - Open Hazardous Drains (F22) – Open hazardous drains will contain leaks and spills of hazardous liquids.
  - Pressure Vessels (P01) – Integrity of pressure vessels will be maintained to safely contain liquids and gases as per design requirements.
  - Heat Exchanger (P02) – Integrity of heat exchangers will be maintained to safely contain liquids and gases as per design requirements.
  - Rotating Equipment (P03) – Rotating equipment maintained to safely contain liquids and gasses as per design requirements.
  - Tanks (P04) – Integrity of tanks will be maintained to safely contain liquids and gases as per design requirements.
  - Piping Systems (P08) – Piping systems will contain associated liquids and gases.
  - Sand Management Systems (P28) - Acoustic sand detectors will ensure the integrity of pressure equipment is not compromised by the presence of sand.
  - • Chemical Injection Systems (P29) – Corrosion inhibitor injection systems will prevent internal damage to equipment is not compromised by the presence of sand.
- Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

Table 12-14: Summary of receptors located in ZoC for Topside Loss of Containment scenario - topside process release (Condensate)

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Operating Standard)																													Hydrocarbon contact and fate (Condensate)			
		Water & Sediment Qualtiy		Marine Primary Producers			Other habitats / Communities								Protected Species									Other Species		Socio-economic								
		Openwater – water quality (prisitine)	Marine Sediment Quality (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Openwater - Productivity / upwelling	Spawning / nursery areas	Non biogenic coral reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks /lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting beaches)	Whale sharks	Seasnakes	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism (including recreational fishing)	Protected Areas / Heritage / Shipwrecks	Offshore Oil & Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10g/m²)	Accumulated hydrocarbon (≥10g/m²)	Entrained hydrocarbon (≥500ppb)	Dissolved hydrocarbon (≥500ppb)
Offshore	Commonwealth waters	✓	✓				✓								✓	✓					✓	✓	✓	✓		✓		✓		✓	✓	x	✓	x
	Montebello CMR	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	x	x	x
Submerged Shoals	Rankin Bank	✓	✓	✓			✓	✓		✓						✓					✓	✓		✓	✓	✓		✓			✓	x	x	x
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		x	x	x	x

A- 25 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by a Loss of Structural Integrity

Source of Risk	**Environmental Value Potentially Impacted**									**Evaluation**		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Topsides • Well Configuration • Pipeline and Riser System • Subsea Infrastructure • Hydrocarbon and Chemical Inventories • Support Vessels Operations	X	XX		X	X	X		X	X	B	1	High

Description of Source of Risk

The release of hydrocarbons as a result of Loss of Structural Integrity is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons contained in the NRC and associated infrastructure.

A loss of containment from the loss of structural integrity includes:

- Extreme environmental conditions (cyclone or earthquake) at the NRC resulting in a loss of structural integrity of the platform and/or loss of hydrocarbon containment
- Impact caused by a marine vessel; and
- Collateral damage to the platform jacket legs, conductors or risers from a sea fire caused by a loss of containment.

A decision type ‘B’ has been applied to this risk under the UKOOA 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 including the bowtie methodology (described in Section 5.3.4) and oil spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The potential consequences related to this event are summarised below.

Extreme environmental conditions (cyclone or earthquake) at the NRC could result in loss of structural integrity of the platform resulting in a hydrocarbon release to the environment. 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. Impact caused by powered collision by a marine vessel could also result in similar damage to the platform and result in a loss of hydrocarbon containment from the platform and/or the marine vessel involved.

Structural damage to the platform 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.

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 NRC are discussed in the relevant sections referenced above. It could also include the worst case hydrocarbon release scenario from the Loss of Marine Vessel Separation MEE if the loss of structural integrity of the NRC were caused by a vessel collision with the platform. Relevant trajectory modelling as applicable to these scenarios is also discussed in the above mentioned sections.

<table>
<tr><th colspan="2">Potential Environmental Impacts</th></tr>
<tr><th>Value</th><th>Description of Potential Environmental Impact</th></tr>
<tr><td>Water Quality
Air Quality
Marine Primary Producers
Other Habitats & Communities
Protected Species
Socio-economic
Protected Areas</td><td>As discussed under Description of Risk, the potential impacts from a hydrocarbon release caused by a Loss of Structural Integrity are those which would result from:
• Well Loss of Containment
• Subsea Loss of Containment
• Topsides Loss of Containment
• Loss of Marine Vessel Separation
The potential impacts are therefore discussed in additional risk assessments. In the event of loss of structural integrity there is the potential for collapse of the platform leading to an incremental increase of the facilities footprint on the seabed. The potential area that would be affected can conservatively be defined as the existing NRC footprint plus 100 m in all directions.
The NRC facilities are located in the NWS Province, an area of broad geomorphological and biological similarity as described within the framework of the Integrated Marine and Coastal Regionalisation of Australia (IMCRA). The NWS Province covers an area of approximately 210,000 km^2 (Baker et al, 2008); the potential area affected by collapse of the NRA/ NRB platforms is a very small portion of this habitat type (approximately 0.00005 %), therefore the potential environmental consequence of the increase in footprint are considered to be insignificant.
Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release.</td></tr>
</table>

Summary of Control Measures

- Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance:
    - Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies.
    - Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea.
    - ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems.
    - ESD System (F06) - ESD systems will shut down plant and equipment.
    - Reservoir Isolation (F07) - Reservoir isolation valves will isolate the reservoir from the facility.
    - SSIV System (F08) – Subsea isolation valves will isolate the inventory in the pipeline from the riser and topsides affecting the riser.
    - Depressurisation (Blowdown) (F09) - Critical BDV will safely depressurise inventories to avoid, or prevent the escalation of a loss of containment.
    - Relief Systems (F21) – Relief systems will protect pressurised equipment, equipment exposed to high pressures and piping from loss of containment.
    - Surface Structures (P07) – Structural integrity of topsides and surface structures will be maintained to ensure availability of critical systems during a major accident or environment event.
    - Substructures (P21) - Structural integrity of substructures will be maintained to ensure availability of critical systems during a major accident or environment event.
- Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

A- 26 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by a Loss of Vessel Separation

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Pipeline and Riser System • Hydrocarbon and Chemical Inventories • Support Vessels	X	X	X	X	X	X		X	X	B	1	High

Description of Source of Risk

The release of hydrocarbons caused by a loss of marine vessel separation is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons contained in NRC subsea and topsides equipment and marine vessels. A loss of containment caused by a loss of marine vessel separation includes:

- Collision by a passing vessel with the NRC platforms due to loss of control (mechanical failure) or human error.
- Collision by a visiting or standby vessel with the NRC platforms when approaching the structure, during manoeuvring due to loss of control (mechanical failure) or human error.

A decision type ‘B’ has been applied to this risk under the *UKOOA* 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 including the Bowtie Methodology and oil spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

In both cases, the implied definition of the event is a significant collision which can cause damage to the platform or the vessel resulting in a hydrocarbon release to the environment. The potential consequences related to this event are summarised below.

Potential consequences include damage/rupture of pipeline or riser potentially causing significant release of hydrocarbon (Subsea Loss of Containment); or damage to the NRC topsides causing significant release of process or non-process hydrocarbon (Loss of Structural Integrity).

Collision of a vessel with the NRC platform could potentially cause significant structural damage (Loss of Structural Integrity); damage/rupture of risers potentially causing significant release of hydrocarbon (Subsea Loss of Containment); or damage to the NRC topsides process and/or non-process vessels potentially causing significant release of hydrocarbon (Topsides Loss of Containment).

The events listed above are applicable representations of worst credible hydrocarbon release scenarios caused by a loss of marine vessel separation, and therefore potential relase scenarios and impacts are as per those discussed in the previous sections. Relevant trajectory modelling as applicable to these scenarios are also discussed in the abovementioned sections.

In addition to the above, there is potential the marine vessel could also sustain sufficient damage from a collision to result in a hydrocarbon release from a loss of containment from its diesel inventory to the marine environment. The worst credible release scenario from a support vessel is deemed as the loss of the largest isolatable tank on the vessel.

Rupture of a tank would require direct collision from the side with enough force to rupture a wing tank. Direct stern and direct bow impacts are unlikely to rupture a fuel tank because the tanks in these areas are protected by an overhang of the deck. The maximum volume likely to be released from rupture of a fuel tank has been estimated to be 105 m^3 on the basis that each wing tank holds approximately 100 to 120 m^3 and a conservative assumption that 80% of the fuel would escape if it was full. This volume is lower than the possible amount of diesel which may be lost as a result of a topside release of non-process hydrocarbon (440 m^3).

Potential Environmental Impacts

Value	Description of Potential Environmental Impact

<table>
<tr><td>Water Quality
Air Quality
Marine Primary Producers
Other Habitats & Communities
Protected Species
Socio-economic
Protected Areas</td><td>Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release.
As discussed under Description of Risk, the potential impacts from hydrocarbon release caused by marine vessel separation are as per those which would result from:
• Well Loss of Containment
• Subsea Loss of Containment
• Topside Loss of Containment
• Loss of Structural Integrity.
The potential impacts are therefore also discussed in the above mentioned sections.
As also mentioned above, the impact arising from the loss of diesel from a supply vessel (105m^3), as a result of vessel collision with the platform would be less than could potentially be lost from diesel stored on the platform (440m^3). Given this, the potential impacts from the worst credible non process topsides hydrocarbon release (based on modelling of 500 m^3 diesel spill at the nearby GWA platform) scenario are considered conservative when considering potential impacts as a result of loss of diesel from a supply vessel. The potential impacts for this scenario are therefore as per discussed Topsides Loss of Containment).
Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release.</td></tr>
<tr><th colspan="2">Summary of Control Measures</th></tr>
</table>

- Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance:
  - Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies.
  - Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea.
  - Fire and Gas Detection (F01) - Fire and gas detection systems will facilitate prevention and response to fire or gas hazards.
  - ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems.
  - ESD System (F06) - ESD systems will shut down plant and equipment.
  - Reservoir Isolation (F07) - Reservoir isolation valves will isolate the reservoir from the facility.
  - SSIV System (F08) – Subsea isolation valves will isolate the inventory in the pipeline from the riser and topsides affecting the riser.
  - Depressurisation (Blowdown) (F09) - Critical BDV will safely depressurise inventories to avoid, or prevent the escalation of a loss of containment.
  - Open Hazardous Drains (F22) – Open hazardous drains will contain leaks and spills of hazardous liquids.
  - Navaids (P33) - Navaids and warning lights will alert marine vessels and aircraft of the position of the facility.
  - Ship Intrusion Detection Systems (P34) – Systems and equipment will detect and alert facility personnel of a potential collision with the facility and respond to a potential collision with the facility.
- Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

A- 27 Non-routine / Accidental Hydrocarbon or Chemical Spills: Hydrocarbon Release caused by Loss of Suspended Load

Source of Risk	Environmental Value Potentially Impacted									Evaluation		
	Water Quality	Marine Sediment Quality	Air Quality	Marine Primary Producers	Other Habitats & Communities	Protected Species	Soil & Groundwater	Socio-Economic	Protected Areas	Consequence	Likelihood	Residual Risk
The key elements of the activity relevant to this source of risk are: • Lifting Operations • Hydrocarbon and Chemical Inventories	X	X	X	X	X	X		X	X	B	1	High

Description of Source of Risk

The release of hydrocarbons caused by a loss of control of suspended load is considered a Major Environment Event. The hazard associated with this MEE is hydrocarbons contained in NRC subsea and topsides equipment and marine vessels.

A loss of containment caused by a loss of control of suspended load includes:

- crane or lifting equipment failure;
- incorrectly slung/excessive loads;
- crane operator error;
- dropped/swingload impacts to topsides during supply vessel loading/offloading operations; and
- dropped anchors/objects from passing vessels onto subsea hydrocarbon equipment.

A decision type 'B' has been applied to this risk under the *UKOOA 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 including the bowtie methodology and oil spill modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The potential consequences related to this event are outlined within:

- Well Loss of Containment
- Subsea Loss of Containment
- Topside Loss of Containment

The events listed above are applicable representations of worst credible hydrocarbon release scenarios caused by a loss of suspended load, and therefore potential release scenarios and impacts are as per those discussed in the previous sections.

Potential Environmental Impacts

Value	Description of Potential Environmental Impact
Water Quality **Air Quality** **Marine Primary Producers** **Other Habitats & Communities** **Protected Species** **Socio-economic** **Protected Areas**	The potential environmental impacts from a hydrocarbon release caused by loss of control of a suspended load are those which would result from: • Well Loss of Containment • Subsea Loss of Containment • Topside Loss of Containment. Refer to the risk assessment of hydrocarbon release caused by well loss of containment for a discussion of the potential environmental impacts from a large scale hydrocarbon release.

Summary of Control Measures
• Compliance with the following NRC SCE Performance Standards. Equipment and systems within these standards will be fit for service, available at all times and implemented to meet the required level of performance: o Critical Communication Systems (E04) - Critical communication systems will facilitate prevention and response to accidents and emergencies. o Environmental Incident Response Equipment (E05) – Satellite tracking drifter buoy will monitor the movement of significant hydrocarbon spills to sea. o Fire and Gas Detection (F01) - Fire and gas detection systems will facilitate prevention and response to fire or gas hazards. o ESD Valves (F05) - ESD valves will isolate hazardous inventories within pipework and riser systems. o ESD System (F06) - ESD systems will shut down plant and equipment. o Reservoir Isolation (F07) - Reservoir isolation valves will isolate the reservoir from the facility. o SSIV System (F08) – Subsea isolation valves will isolate the inventory in the pipeline from the riser and topsides affecting the riser. o Depressurisation (Blowdown) (F09) - Critical BDV will safely depressurise inventories to avoid, or prevent the escalation of a loss of containment. o Open Hazardous Drains (F22) – Open hazardous drains will contain leaks and spills of hazardous liquids. o Surface Structures (P07) – Structural integrity of topsides and surface structures will be maintained to ensure availability of critical systems during a major accident or environment event. o Cranes (P15) – Crane lifting operations will be safely performed to minimise potential for dropped objects. o Lifting Equipment (P20) - Lifting and lifted equipment will be in a safe and serviceable condition to prevent dropped objects. • Deviations from requirements of NRC SCE Performance Standards will be managed in Woodside's technical management of change system to ensure the Environmental Performance Objective specified by the EP is maintained.

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

Table B1 Impacts and Risks Evaluation Summary										
Response Strategy	**Environmental Value Potentially Impacted**							**Evaluation**	**Controls**	
	Soil & Groundwater	Marine Sediment Quality	Water Quality	Air Quality	Ecosystems/Habitat	Species	Socio-Economic	ALARP Tools[7]	Acceptable	Existing Control Measure (system, procedure, person, equipment)
Vessel Operations to support all response strategies		X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Anchoring during response-** Appropriate anchoring locations and procedures. **Vessels during response -** Appropriate vessels used for shallow water response. **Vessels and secondary contamination -** Secondary containment (booming) & cleaning of contaminated vessels
Source Control		X	X	X	X	X	X	Good Practice Professional Judgement	Yes	The risks and impacts of drilling a relief well described in the Appendix A for drilling activities
Monitor and Evaluate		X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Shoreline surveys-** Shoreline surveys conducted when appropriate.
Containment and Recovery		X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Decanting** - will be conducted in accordance with AMSA guidance including: daylight hours only, discharge into the apex of the boom; only following a minimum residence time of 30 minutes **Waste Management -**Waste management contract with Waste Contractor **Obstruction of Wildlife-** Appropriate boom procedures will be implemented.
Shoreline Protection	X	X	X	X	X	X	X	Good Practice	Yes	**Obstruction of Wildlife**

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[7] Refer to Section 2.3.5 of the EP for ALARP tool definitions

and Deflection								Professional Judgement		Appropriate boom procedures will be implemented. **Anchoring boom** Appropriate procedures in place to anchor protection and deflection equipment
Shoreline Cleanup	X	X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Shoreline clean up- site access–** shoreline access considerations will be made during shoreline clean-up operations. **Selection of Clean-up methods-** Shoreline clean-up methods will be selected based on shoreline type and conditions of the clean-up site.
Oiled Wildlife		X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Hazing and pre-emptive capture-** Hazing and pre-emptive capture techniques will be conducted in accordance with the Oiled Wildlife Response Plan (OWRP) **Oiled Wildlife Techniques-** Oiled wildlife techniques are to be advised by the DPAW wildlife advisor as per the OWRP **Presence of personnel-** Presence of personnel and equipment **Oiled Wildlife Response Plan-DPaW Personnel.** oiled wildlife response is implemented in accordance with the OWRP
Waste Management	X	X	X	X	X	X	X	Good Practice Professional Judgement	Yes	**Waste Management contract-** Waste management transport will follow environment Protection Regulations 2004 and the Woodside Waste Management Support **Waste Treatment** Waste will be treated using pre-determined strategies via the contact with Waste Contractor

Description of Oil Spill Response Risk

The environmental risk is the additional impact to the environment from the implementation of the oil spill response strategies during an oil spill response.

Potential Impacts

Response activities can result in:

- Spreading of hydrocarbons further beyond the zone of contamination (e.g. secondary contamination due to hull contamination of response vessels);
- Negative environmental impacts associated with implementing the response strategy, potentially outweighing the benefit of conducting the strategy.
- Inadequate surveillance leading to poor information and unforeseen impacts; or
- Inappropriate response strategy implemented and additional sensitive receptors impacted (e.g. use of dispersants when containment and recovery would have been of greater benefit).

This section assesses the available spill response strategies identifying and evaluating the environmental impact.

Risk assessment of oil spill response strategies

The acceptability of the potential environmental impacts and risks associated with the following selected oil spill response strategies have been evaluated in accordance with Woodside's Risk Methodology and Regulations 13(5) and 13(6) of the OPGGS(E)R:

- Source control;
- Monitor and evaluate;
- Containment and recovery;
- Shoreline protection and deflection;
- Shoreline clean-up; and
- Oiled wildlife response.

A number of risks assessed in **Appendix A** are applicable to the oil spill response strategy implementation. These are:

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

The following sections address additional risks to the environment from the implementation for the oil spill response strategies not previously assessed.

Source Control - Description of Risk

In the event of a worst case loss of well containment, source control would be the primary response strategy to reduce the volume of hydrocarbons released, potentially involving the following activities:

- Vessel based deployment of the subsea first response toolkit (SFRT) to facilitate debris clearance by ROV
- Vessel based deployment of a capping stack
- Well intervention/relief well drilling.

Source Control - Potential Impacts

The risks and impacts of drilling a relief well are similar to those described in **Appendix A** for drilling activities. The remaining risks to the environment from vessel activities associated with the implementation of the Source control response fall within the scope of the EP.

Adopted controls are summarised in **Table B1**.

Monitor and Evaluate – Description of Risk

Field-based activities undertaken during the Monitor and Evaluate Response Strategy including monitoring, surveillance and reconnaissance involving vessel, aircraft operations, and shoreline surveys present risks to the environment. Additional risks associated with the monitor and evaluate response not included within the scope of the EP include:

Seabed disturbance that may be associated with 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 to shoreline response teams.

Presence of personnel during shoreline surveys resulting in disturbance to wildlife and habitats

During implementation of shoreline surveys associated with OM04, responders are required to survey shoreline receptor locations prior to contact from the hydrocarbon spill. As a result there is potential for environmental impacts associated with the presence of personal in environmentally sensitive locations.

Monitor and Evaluate - Potential Impacts

Seabed disturbance that may be associated with Vessel anchoring

Anchoring in the nearshore environment, such as the Priority Protection Areas, will have potential to impact coral reef, seagrass beds and benthic communities in these areas. Impacts would be highly localised (restricted to the footprint of the vessel anchor) and temporary, with full recovery expected.

Presence of personnel during shoreline surveys resulting in disturbance to wildlife and habitats. The impacts associated with human presence on shorelines during shoreline surveys include:

- Damage to vegetation/habitat in order to gain access to areas
- Damage or disturbance to wildlife and habitats during shoreline surveys.
- Removal of surface layers of intertidal sediments (potential habitat depletion).
- Excessive removal of substrate can have erosion and instability effects.

Adopted controls are summarised in **Table B1**.

Containment and Recovery – Description of Risk

A containment and recovery typically involves the deployment of boom and skimmers from suitable vessels, as well as the collection, transfer and disposal of oily water recovered during the response.

Additional risks associated with the containment and recovery response not included within the scope of the EP include:

Waste management leading to secondary contamination

It is possible for an unplanned release of recovered oily water to the marine environment causing secondary contamination during transfer, decanting or transport activities that form part of a containment and recovery response.

Response equipment obstructing wildlife

Containment and recovery equipment such as booms and skimmers have the potential to act as obstacles or trap wildlife.

Vessel anchoring – Evaluated in Monitor and Evaluate

Containment and Recovery - Potential Impacts

Secondary Contamination

Secondary contamination refers to the release of hydrocarbons back to the environment during a response (potentially during containment and recovery, oiled wildlife response and shoreline clean up). The largest volume of oily water that could be spilt is conservatively considered to be 200 m^3, i.e. the equivalent to the maximum oily water volume recovered from one containment and recovery operation per day. Given the application of a conservative bulking factor of 10 when calculating the hydrocarbon content of the oily water mixture, the maximum volume of hydrocarbon that could be released is 20 m3. The biological consequences of such a small volume spill on identified open water sensitive receptors would be expected to be similar to those associated with the unplanned release of hydrocarbons as a result of a bunkering scenario, and relate to the potential for minor impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area and no impacts to commercial fisheries are expected.)

Section 5.2 describes the detailed potential impacts from a hydrocarbon spill; however, the extent of the ZoC associated with a spill of recovered oily water from a containment and recovery response will be much reduced in terms of spatial and temporal scales, and hence, the potential impacts are expected to be very minor.

Waste

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

- Liquids (recovered oil/water mixture),
- Semi-solids/solids (oily solids),
- Debris (e.g. seaweed, woods, plastics),

If not managed and disposed of correctly, wastes generated during the response have the potential for secondary contamination similar to that described above, impacts to wildlife through contact with or ingestion of waste materials and contamination risks if not disposed of correctly onshore.

Response equipment obstructing wildlife

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

Vessel anchoring – Evaluated in Monitor and Evaluate.

Adopted controls are summarised in **Table B1**.

Shoreline Protection and Deflection - Description of Risk

Shoreline protection and deflection consists of the placement of protection or deflection booms on and near a shoreline to reduce the potential volume of surface oil contacting or spreading along shorelines, which may reduce the scale of shoreline cleanup. Oil contained by the booms would be collected where practicable.

Shoreline protection and deflection techniques recommended for different shoreline types and conditions that are considered to have a net environmental benefit for this Petroleum Activities Program include manual and mechanical cleanup. Additional risks associated with the shoreline protection and deflection response not included within the scope of the EP include:

- Equipment/material/worker transport
- Human Presence (boom deployment)
- Waste Generation/ Disposal

Shoreline Protection and Deflection - Potential Impacts

An evaluation of the impacts not within the scope of the EP are as followed:

Equipment/material/worker transport

- Response equipment such as booms could act as obstacles or trap wildlife (restrict wildlife movement)
- Minor disturbance to substrate
- Diverted oil may cause heavy shoreline contamination downwind and down current disturbs beach sediment

Human Presence (boom deployment)

- Vehicle and foot traffic to and from boom sites could disturb wildlife and damage habitat
- Compaction of shoreline

Adopted controls are summarised in **Table B1.**

Shoreline Clean up – Description of Risk

Shoreline cleanup consists of different manual and mechanical recovery techniques to remove hydrocarbons and contaminated debris from a shoreline to minimise ongoing environmental contamination and impact. Shoreline cleanup techniques recommended for different shoreline types and conditions that are considered to have a net environmental benefit for this Petroleum Activities Program include manual and mechanical cleanup.

Additional risks associated with the shoreline cleanup response not included within the scope of the EP include:

- Mechanical cleaning

- Human Presence (manual cleaning)
- Sediment reworking
- Vegetation cutting

Shoreline Clean up - Potential Impacts

An evaluation of the impacts not within the scope of the EP are as follows:

Mechanical cleaning

- Damage to shoreline from machinery.
- Compaction of sediment from heavy machinery causing hydrocarbons to be buried or penetrate sediment further.
- Damage to vegetation/habitat in order to gain access for heavy machinery to area
- Removal of surface layers of intertidal sediments (potential habitat depletion).
- Excessive removal of substrate can have erosion and instability effects.

Human Presence (manual cleaning)

- Compaction of human presence causing hydrocarbons to be buried or penetrate sediment further.
- Damage to vegetation/habitat in order to gain access to areas
- Removal of surface layers of intertidal sediments (potential habitat depletion).
- Excessive removal of substrate can have erosion and instability effects.

Sediment reworking

- Remobilised oil could have impacts elsewhere causing secondary contamination, further

Vegetation cutting

- Cutting back too much vegetation could allow more oil to penetrate substrate.
- Removing too much vegetation or slow growing vegetation can have negative impact for wildlife (habitat loss).

Adopted controls are summarised in **Table B1**.

Oiled Wildlife – Description of Risk

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

Impacts to wildlife through:

- 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

- Hazing of wildlife
- Oiled wildlife carcasses/animals

Oiled Wildlife - Potential Impacts

An environmental impact assessment, controls, environmental performance standards and measurement criteria for the sources of risk within the scope of the EP are detailed in the **Section 5.**

An evaluation of the impacts not within the scope of the EP are as follows:

Capturing wildlife

- Inefficient capture techniques has potential to cause undue stress, exhaustion or injury to wildlife
- Pre-emptive capture could cause undue impacts when oiling is not certain

Transportation

- Inefficient transport techniques has potential to cause undue injury, stress and thermoregulation pressures to wildlife.

Stabilisation of wildlife

- Inefficient stabilisation of wildlife techniques has potential to cause injury to wildlife and thermoregulation stress, In addition to potential for euthanasia during the triage process.

Cleaning and rinsing of oiled wildlife

- Inefficient cleaning and rinsing techniques has potential to cause injury and exhaustion of wildlife with potential to remove water-proofing feathers.

Rehabilitation (e.g. diet, cage size, housing density)

- Inefficient rehabilitation techniques has potential to cause injury and thermoregulation stress of wildlife. Additionally, inappropriate captive diet could result in further injury to wildlife.

Release of treated wildlife

- Potential for undue stress to wildlife if released in an unfamiliar site.
- Potential for rehabilitated wildlife to return to the oiled area of capture.
- Potential of stress adjusting to the release site.

Hazing of wildlife

- Inefficient hazing techniques has the potential to cause undue stress to wildlife.
- Potential for wildlife to return to area post hazing which could result in further hazing being required or could lead to impacts from the spill if it coincides with the spill hitting the location.
- Potential for wildlife to relocate to an undesired location where potential for impacts to wildlife are greater than the initial location.

Wildlife carcasses

- Inefficient disposal of wildlife carcasses could result in secondary contamination.
- Waste generation and disposal and secondary contamination

Adopted controls are summarised in **Table B1.**

APPENDIX C: SUMMARY OF STAKEHOLDER FEEDBACK AND WOODSIDE’S ASSESSMENTS AND REPONSES

Feedback from Relevant and Interested Stakeholders on the Petroleum Activities Program

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
AMSA	Email with factsheet	**Date: 17 June 2016** AMSA confirmed that minimal traffic should be encountered, with the majority of vessels undertaking supporting activities for the offshore infrastructure. AMSA requested the pipe laying vessel notify AMSA's Joint Rescue Coordination Centre (JRCC) through rccaus@amsa.gov.au (Phone: 1800 641 792 or +61 2 6230 6811) for radio-navigation warnings 24-48 hours before operations commence. AMSA's JRCC will require the MODU's details (including vessel name, callsign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone) and area of operation and need to be advised when operations start and end. Additionally, the Australian Hydrographic Service must be contacted through datacentre@hydro.gov.au no less than four working weeks before operations commence for the promulgation of related Notices To Mariners (NTM). **Date: 28 July 2016** AMSA acknowledged clarification of notification activities and confirmed advice provided by AMSA on 17 June 2016 remains extant. AMSA also provided advice that an update to their website includes a section on promulgation of Maritime Safety Information.	In relation to the advice provided by AMSA, these notification activities will be undertaken by the Persephone Project team in accordance with the accepted Persephone Development environment plan. The revision to the accepted North Rankin Complex environment plan relates to the start-up of Persephone and the ongoing operation of the North Rankin Complex, which would essentially take place after the Persephone Project has completed its construction activities requiring the vessel activities described in AMSA's advice. No further action required under this environment plan. AMSA and Australian Hydrographic Service to be contacted as required in relation to Persephone Project activities.
AMSA (Marine Pollution)	Email with factsheet; copy of draft revision to North Rankin Complex Oil Pollution First Strike Plan.	No response at the time of submission.	AMSA has been provided with a copy of draft revision to North Rankin Complex Oil Pollution First Strike Plan., which is also relevant to and supports submission of this environment plan, and is supported by our Oil Pollution Emergency Arrangements (Australia), for which AMSA is on our controlled document distribution list. No further action required. Woodside has a signed memorandum of understanding with AMSA to support its role as combat agency. For ship-sourced spills (in Cwth waters) AMSA retains

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
			Combat Agency responsibility for all ship-sourced marine pollution incidents. Woodside will provide support to AMSA. For non-ship-sourced spills and in accordance with the MoU, AMSA on formal request of the appointed Incident Coordinator will coordinate the resources of the National Plan.
APPEA	Email with factsheet	No response at the time of submission.	Woodside believes it has given APPEA adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Australian Conservation Foundation	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Australian Conservation Foundation adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Australian Fisheries Management Authority	Email, Fact Sheet and map depicting relevant State and Commonwealth fishing zones sent 18 July 2013	No feedback received	N/a
Australian Fisheries Management Authority (AFMA)	Email with factsheet and fisheries map	No response at the time of submission.	There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. No further action required.
Australian Hydrographic Service	Email with factsheet	**Date: 11 July 2016** The Australian Hydrographic Services acknowledged receipt of information in relation to the revision to the accepted North Rankin Complex Environment Plan.	Woodside believes it has given the Australia Hydrographic Service adequate time and information upon which to provide feedback about the proposed activity. No further action required under this environment plan. AMSA and Australian Hydrographic Service to be contacted as required in relation to Persephone Project activities.
Australian Maritime Safety Authority	Email, Fact Sheet and shipping traffic map depicting	Date:	Date:

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
(maritime safety)	shipping fairways and shipping intensity in the area sent 18 July 2013	22 July 2013 Feedback summary: Feedback provided was not in relation to the NRC.	30 July 13 Feedback summary: Email and comments noted.
Border Protection Command	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Border Protection Command adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Commonwealth fisheries Southern Bluefin Tuna Western Tuna and Billfish Western Skipjack	Email, Fact Sheet and map depicting relevant State and Commonwealth fishing zones sent 18 July 2013	No feedback received	There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. No action required.
Commonwealth Fisheries Association	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Commonwealth Fisheries Association adequate time and information upon which to provide feedback about the proposed activity. There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. No further action required.
Department of Defence – Defence Property Services Group	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Department adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Department of Environment	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Department of Environment adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Department of Fisheries (Western Australia)	Email, Fact Sheet and map depicting relevant State and Commonwealth fishing zones	Date: 30/08/13 Feedback summary:	Date: 06/09/13 Feedback summary:

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
	sent 18 July 2013 Letter, Fact Sheet and map depicting relevant State and Commonwealth fishing zones sent 18 July 2013 as previously directed by the Department of Fisheries and Western Australian Fishing Industry Council	The Department of Fisheries verbally requested further information on the NRC activities listed on the fact sheet in order to provide informed feedback. Date: 11/09/13 Feedback summary: The Department of Fisheries provided a response noting that they believed they were a 'relevant' stakeholder. The Department provided the following advice: Six State fisheries have interest in the area Ongoing consultation with fisheries and representative bodies should continue An Operational and Scientific Monitoring Program (OSMP) should be in place Key fish species (including spawning events) should be included in the EP Discharges are managed and recorded as per procedures Invasive marine species management plan in place Information provided by the Department of Fisheries is acknowledged in the EP Date: 14/02/14 Feedback summary: The Department noted the advice provided on 13 September 2013 and confirmed that it remains current. This advice is valid for the duration of the North Rankin Complex operations described in the associated Environment Plan.	Further information provided. Assessment of feedback: As per the Department of Fisheries letter, Woodside has acknowledged in the EP: The active and in-active State fisheries in the EP (inactive fisheries have been noted and ongoing consultation with fisheries representative bodies will ensure any activity by those parties is identified) Woodside has an appropriate OSMP Spawning grounds and nursery areas for key species are noted Woodside has appropriate record and notification processes in place for a loss of containment Woodside has in force an Invasive Marine Species Management Plan. Date: 23 January 2014 Feedback summary: Further to the advice provided by the Department of Fisheries (DoF) on 13 September 2013 could DoF please advise if the information and advice is still valid as it expired on 11 December.
Department of Fisheries	Email with factsheet and fisheries map. Telephone conversation (21/7).	**Date: 20 July 2016** DoF acknowledged receipt of information on the revision of the North Rankin EP for the start-up and operation of the Persephone Project, and had no comment to make at this stage.	There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. Woodside will continue to engage regularly with DoF on

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
			upcoming activities and believes it has given the DoF adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Department of Industry	Email with factsheet	**Date: 12 July 2016** The Department acknowledged receipt of information in relation to the North Rankin Complex Operations Environment Plan and appreciated being advised on the status of current activities and the relevant contact details.	No further action required.
DMP (representing the Minister for Mines and Petroleum)	Email with Fact Sheet sent 18 July 2013	Date: 24/07/13 Feedback summary: The DMP acknowledges receipt of the notification dated 18 July 2013, for the proposed Greater Western Flank Phase 1 Subsea Installation and Project Commissioning, and the revised NRC Operations activities. DMP has reviewed the information provided and does not require any further information at this time. DMP notes the Greater Western Flank Phase 1 Subsea Installation and Project Commissioning EP, and the NRC Operations EP, will be assessed under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*, by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). DMP notes a separate EP is required for the petroleum activity in State waters, and does not form part of the scope of the NRC Operations EP to be assessed by NOPSEMA under the abovementioned regulations.	N/a
Department of Mines and Petroleum	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Department of Mines and Petroleum adequate time and information upon which to provide feedback about the proposed activity. No further action required

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Department of Resources, Energy and Tourism (representing the Minister for Resources and Energy)	Email with Fact Sheet sent 18 July 2013	No feedback received	N/a
Department of Transport (Western Australia)	Email with Fact Sheet sent 18 July 2013 Meeting held with Department of Transport on spill preparedness on 29 July Woodside provided a copy of the Activity First Strike to DoT.	No feedback received.	Woodside will continue to progress discussions with WA DoT to ensure that any feedback received is incorporated into the Activity First Strike Plan and NEBA.
Western Australian Department of Transport	Email with factsheet; copy of draft revision to North Rankin Complex Oil Pollution First Strike Plan.	**Date: 25 July 2016** DoT acknowledged receipt of the draft revision to North Rankin Complex Oil Pollution First Strike Plan.	Woodside maintains a regular dialogue with DoT. DoT has previously been provided with a copy of Woodside's Oil Pollution First Strike Plan for the North Rankin Complex, which is also relevant to and supports submission of this environment plan, and is supported by our Oil Pollution Emergency Arrangements (Australia), for which DoT is on our controlled document distribution list. Woodside will continue to progress discussions with WA DoT to ensure that any feedback received is incorporated into the North Rankin Complex Oil Pollution First Strike Plan.
International Fund for Animal Welfare	Email with factsheet	No response at the time of submission.	Woodside believes it has given the International Fund for Animal Welfare adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Pearl Producers Association	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Pearl Producers Association adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Recfishwest	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Recfishwest

Organisation	Consultation	Stakeholder Feedback	Woodside Assessment and Response
			adequate time and information upon which to provide feedback about the proposed activity. No further action required.
Western Australian Fisheries Mackerel Pilbara NCDSF Onslow Prawn	Email, Fact Sheet and map depicting relevant State and Commonwealth fishing zones sent 18 July 2013 Letter, Fact Sheet and map depicting relevant State and Commonwealth fishing zones sent 18 July 2013 as previously directed by the Department of Fisheries and Western Australian Fishing Industry Council	Response: Old Brown Dog (Pilbara Trap Fishery) Date: 24/07/13 Feedback summary: Feedback provided was not in relation to the NRC.	N/a
Western Australian Fisheries Western Australian Mackerel Fishery. Pilbara NCDSF Fishery Onslow Prawn Fishery	Letter with factsheet and fisheries map	No response at the time of submission.	There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. No action required.
Western Australian Fishing Industry Council	Email with factsheet; quarterly meeting held with Woodside and WAFIC on 15/6 included discussion on upcoming activities including revision to accepted North Rankin Complex environment plan.	**Date: 28 June 2016** WAFIC understand the revisions to the previously approved EP are more of the “business as usual” activities. WAFIC expressed interest in activities associated with drilling and subsea installations where these activities require commercial fisher notification.	Woodside maintains a regular dialogue with WAFIC on upcoming activities where there is a potential impact on commercial fishers. There is limited historical fishing activity conducted in proximity to the existing and long-established North Rankin Complex. No material change to potential impacts to fishers. No further activities required under this environment plan.
Wilderness Society	Email with factsheet	No response at the time of submission.	Woodside believes it has given the Wilderness Society adequate time and information upon which to provide feedback about the proposed activity. No further action required.

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WWF	Email with factsheet	No response at the time of submission.	Woodside believes it has given the WWF adequate time and information upon which to provide feedback about the proposed activity. No further action required.