Okha
Floating Production Storage and Offtake Facility
Operations Environment Plan

Production Division
Revision 5
November 2019

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TABLE OF CONTENTS

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LIST OF TABLES

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LIST OF FIGURES

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1. INTRODUCTION

1.1 Overview

Woodside Energy Limited (Woodside) is the operator of the Okha floating production, storage and offtake (FPSO) facility and infrastructure in the Cossack, Wanaea, Lambert, and Hermes (CWLH) fields, located off the coast of Western Australia (WA) in Production Licences WA-16-L, WA-9-L, WA-11-L. The fields lie 125–145 km north-west of Karratha, on the inner continental shelf in water depths of 75–135 m.

The Okha FPSO is located in 80 m of water, stationed over the central area of the Wanaea field, ~32 km east of the North Rankin Complex (NRC) and 54 km east of the Goodwyn Alpha (GWA) platform. The subsea production systems comprise thirteen wells linked to subsea manifolds through flexible jumper tie-ins. The Okha FPSO is connected to the subsea infrastructure through a riser turret, subsea risers, and mooring system, and exports gas to North Rankin Alpha (NRA) through the Wanaea Cossack gas export pipeline (WC GEL) where it is subsequently transported to the Karratha Gas Plant (KGP).

The Okha processing system has been designed for a maximum throughput of 60,000 bbl of oil per day, and treatment of 100,000 bbl of produced water (PW) per day (total fluid limit is 150,000 bbl/day). The gas compression system has a maximum capacity of 82 million standard cubic feet per day (MMscfd).

The Okha FPSO was fabricated with a new rigid arm structure, giving it the capability to connect to the riser turret mooring (RTM) system. The RTM system is made up of a riser column, eight anchor chains, and associated gravity anchor boxes, and it allows the vessel to freely weathervane. When connected, the bottom of the column is nominally 30 m above the seabed.

This Environment Plan (EP) has been prepared as part of the requirements under the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (referred to as the Environment Regulations), as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

In accordance with the requirements of Regulation 19 of the Environment Regulations, Woodside has submitted a revision of the Okha Operations EP to NOPSEMA at least 14 days before the end of the five-year period from the original acceptance under Regulation 11 of the Environment Regulations (i.e. 10 December 2014 – NOSPEMA Reference 2785).

1.2 Defining the Petroleum Activity

The Petroleum Activities Program, outlined in Section 1.4, constitutes a petroleum activity as defined in Regulation 4 of the Environment Regulations. As such, an EP is required.

1.3 Purpose of the Environment Plan

In accordance with the objectives of the Environment Regulations, the purpose of this EP is to demonstrate that:

- the potential environmental impacts and risks (planned (routine and non-routine) and unplanned) that may result from the Petroleum Activities Program are identified
- appropriate management controls are implemented to reduce impacts and risks to a level that is ‘as low as reasonably practicable’ (ALARP) and acceptable
- the Petroleum Activities Program is carried out in a manner consistent with the principles of ecologically sustainable development (ESD) (as defined in Section 3A of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act]).

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This EP describes the process and resulting outputs of the risk assessment, whereby impacts and risks are managed accordingly.

The EP defines activity-specific environmental performance outcomes, standards, and measurement criteria. These form the basis for monitoring, auditing, and managing the Petroleum Activities Program to be undertaken by Woodside and its contractors. The implementation strategy (derived from the decision support framework tools) specified in this EP provides Woodside and NOPSEMA with the required level of assurance that impacts and risks associated with the activity are reduced to ALARP and are acceptable.

1.4 Scope of the Environment Plan

The scope of this EP covers the Petroleum Activities Program for a period of up to five years and includes these activities associated with the Okha FPSO:

- routine production
- routine inspection, monitoring, maintenance and repair (IMMR) of the FPSO and associated subsea infrastructure
- intermittent operations and suspension of production
- supporting activities associated with the activities defined above (e.g. vessel operations, helicopter transfers)
- abandoned wells, and light well intervention
- non-routine and unplanned activities and incidents associated with the above.

The infrastructure covered by this EP includes the:

- WC GEL
- Okha FPSO (while in the Operational Area)
- RTM mooring system
- wells associated subsea infrastructure tied back to the Okha FPSO
- temporarily abandoned exploration wells (Lambert 5ST1, Cossack-1, Goodwyn-6 and Angel-1).

Section 3 describes in detail the infrastructure and activities covered by this EP. A decommissioning plan will be developed prior to decommissioning the FPSO and will be submitted to the Environment Regulator for acceptance. The risks associated with removing redundant equipment prior to total FPSO decommissioning will be undertaken and managed in accordance with the requirements of this EP.

1.5 Environment Plan Summary

An EP summary will be prepared based on the material provided in this EP. Table 1-1 summarises the content that will be provided within the EP summary, as required by Regulation 11(4).

Table 1-1: EP summary

EP Summary material requirement	Relevant section of this EP containing EP Summary material
The location of the activity	Section 3.3, pages 44–44
A description of the receiving environment	Section 4, pages 71–159
A description of the activity	Section 3, pages 41–71
Details of the environmental impacts and risks	Section 6, pages 175–402
The control measures for the activity	Section 6, pages 175–402

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EP Summary material requirement	Relevant section of this EP containing EP Summary material
The arrangements for ongoing monitoring of the titleholder's environmental performance	Section 7.5, pages 421–428
Response arrangements in the oil pollution emergency plan	Section 7.8, pages 433–437, and Appendix D
Consultation already undertaken and plans for ongoing consultation	Section 5, pages 159–175
Details of the titleholder's nominated liaison person for the activity	Section 1.8, pages 18–19

1.6 Structure of the Environment Plan

The EP has been structured to reflect the process and requirements of the Environment Regulations, as outlined in Table 1-2.

Table 1-2: EP process phases, applicable Environment Regulations and relevant section of EP

Criteria for acceptance	Content Requirements/Relevant Regulations	Elements	Section of EP
Regulation 10A(a): is appropriate for the nature and scale of the activity	Regulation 13: Environmental Assessment Regulation 14: Implementation strategy for the environment plan Regulation 16: Other information in the environment plan	The principle of 'nature and scale' applies throughout the EP	Section 2 Section 3 Section 4 Section 5 Section 6 Section 7
Regulation 10A(b): demonstrates that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable	Regulation 13(1)–13(7): 13(1) Description of the activity 13(2)(3) Description of the environment 13(4) Requirements 13(5)(6) Evaluation of environmental impacts and risks 13(7) Environmental performance outcomes and standards Regulation 16(a)–16(c): A statement of the titleholder's corporate environmental policy A report on all consultations between the titleholder and any relevant person	Set the context (activity and existing environment) Define 'acceptable' (the requirements, the corporate policy, relevant persons) Detail the impacts and risks Evaluate the nature and scale Detail the control measures – ALARP and acceptable	Section 1 Section 2 Section 3 Section 4 Section 5 Section 6 Section 7
Regulation 10A(c): demonstrates that the environmental impacts and risks of the activity will be of an acceptable level			
Regulation 10A(d): provides for appropriate environmental performance outcomes, environmental performance standards and measurement criteria	Regulation 13(7): Environmental performance outcomes and standards	Environmental Performance Objectives (EPOs) Environmental Performance Standards (EPSs) Measurement Criteria (MC)	Section 6

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Criteria for acceptance	Content Requirements/Relevant Regulations	Elements	Section of EP
Regulation 10A(e): includes an appropriate implementation strategy and monitoring, recording and reporting arrangements	Regulation 14: Implementation strategy for the environment plan	Implementation strategy, including: • systems, practices and procedures • performance monitoring • Oil Pollution Emergency Plan (OPEP) and scientific monitoring • ongoing consultation.	Section 7 Appendix D
Regulation 10A(f): does not involve the activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, being undertaken in any part of a declared World Heritage property within the meaning of the EPBC Act	Regulation 13 (1)–13(3): 13(1) Description of the activity 13(2) Description of the environment 13(3) Without limiting [Regulation 13(2)(b)], particular relevant values and sensitivities may include any of the following: (a) the world heritage values of a declared World Heritage property within the meaning of the EPBC Act; (b) the national heritage values of a National Heritage place within the meaning of that Act; (c) the ecological character of a declared Ramsar wetland within the meaning of that Act; (d) the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act; (e) the presence of a listed migratory species within the meaning of that Act; (f) any values and sensitivities that exist in, or in relation to, part or all of: (i) a Commonwealth marine area within the meaning of that Act; or (ii) Commonwealth land within the meaning of that Act.	No activity, or part of the activity, undertaken in any part of a declared World Heritage property	Section 3 Section 4 Section 6
Regulation 10A(g): (i) the titleholder has carried out the consultations required by Division 2.2A (ii) the measures (if any) that the titleholder has adopted, or proposes to adopt, because of the consultations are appropriate	Regulation 11A: Consultation with relevant authorities, persons and organisations, etc. Regulation 16(b): A report on all consultations between the titleholder and any relevant person	Consultation in preparation of the EP	Section 5

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Criteria for acceptance	Content Requirements/Relevant Regulations	Elements	Section of EP
Regulation 10A(h): complies with the Act and the regulations	Regulation 15: Details of the Titleholder and liaison person Regulation 16(c): Details of all reportable incidents in relation to the proposed activity.	All contents of the EP must comply with the Act and the regulations	Section 1.6 Section 7.7

1.7 Description of the Titleholder

Woodside is the pioneer of the LNG industry in Australia and one of the largest Australian natural gas producers. Woodside Energy Ltd has a global portfolio and is recognised for its world-class capabilities as an integrated upstream supplier of energy. Woodside is the operator of the Okha FPSO and associated infrastructure in the Cossack Wanaea Lambert Hermes (CWLH) Joint Venture, on behalf of itself and its joint venture participants —BHP Billiton Petroleum (North West Shelf) Pty. Ltd., BP Developments Australia Pty Ltd, Chevron Australia Pty. Ltd, and Japan Australia LNG (MIMI) Pty. Ltd. Temporarily abandoned exploration wells (Lambert 5ST1, Cossack-1, Goodwyn-6 and Angel-1) are also operated by Woodside in the North West Shelf (NWS) Joint Venture, on behalf of itself and its joint venture participants—Shell Australia Pty. Ltd., BHP Billiton Petroleum (North West Shelf) Pty. Ltd., BP Developments Australia Pty Ltd, Chevron Australia Pty. Ltd, CNOOC NWS Private Ltd, and Japan Australia LNG (MIMI) Pty. Ltd. Woodside is the Titleholder for this activity (refer to Table 3-1 for a list of petroleum titles associated with the Petroleum Activities Program).

Woodside's mission is to deliver superior shareholder returns through realising its vision of becoming a global leader in upstream oil and gas. Wherever Woodside works, it is committed to living its values of integrity, respect, working sustainably, discipline, excellence, and working together.

Woodside's operations are characterised by strong safety and environmental performance in remote and challenging locations.

Through collaboration, Woodside leverages its capabilities to progress its growth strategy. Since 1984, the company has been operating the landmark Australian project, the North West Shelf, which is one of the world's premier liquefied natural gas (LNG) facilities. In 2012, Woodside added the Pluto LNG Plant to its onshore operating facilities.

Woodside has an excellent track record of efficient and safe production. Woodside strives for excellence in safety and environmental performance and continues to strengthen relationships with customers, partners, co-venturers, governments, and communities to ensure they are a partner of choice. Further information about Woodside can be found at http://www.woodside.com.au.

1.8 Details of Titleholder, Liaison Person and Public Affairs Contact

In accordance with Regulation 15 of the Environment Regulations, details of the titleholder, liaison person and arrangements for the notification of changes are described below.

1.8.1 Titleholder

Woodside Energy Limited

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

ACN: 63 005 482 986

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1.8.2 Activity Contact

Gerard Ransom

Okha FPSO Asset Manager

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

E: feedback@woodside.com.au

1.8.3 Nominated Liaison Person

Daniel Clery

Corporate Affairs Manager

11 Mount Street

Perth, Western Australia

T: 08 9348 4000

E: feedback@woodside.com.au

1.8.4 Arrangements for Notifying Change

If the titleholder, titleholder's nominated liaison person, or the contact details for the titleholder or the liaison person change, then NOPSEMA will be notified of the change in writing within two weeks or as soon as practicable.

1.9 Woodside Management System

The Woodside Management System (WMS) provides a structured framework of documentation to set common expectations governing how all employees and contractors at Woodside will work. Many of the standards presented in Section 6 are drawn from the WMS documentation, which comprises four elements: Compass and Policies; Expectations; Processes and Procedures; and Guidelines, as outlined below (and illustrated in Figure 1-1).

- **Compass and Policies**: Set the enterprise-wide direction for Woodside by governing our behaviours, actions, and business decisions and ensuring we meet our legal and other external obligations.
- **Expectations**: Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and provide the basis for developing processes and procedures.
- **Processes and Procedures**: Processes identify the set of interrelated or interacting activities that transforms inputs into outputs, to systematically achieve a purpose or specific objective. Procedures specify what steps, by whom, and when required to carry out an activity or a process.
- **Guidelines**: Provide recommended practice and advice on how to perform the steps defined in Procedures, together with supporting information and associated tools. Guidelines provide advice on: how activities or tasks may be performed; information that may be taken into consideration; or, how to use tools and systems.

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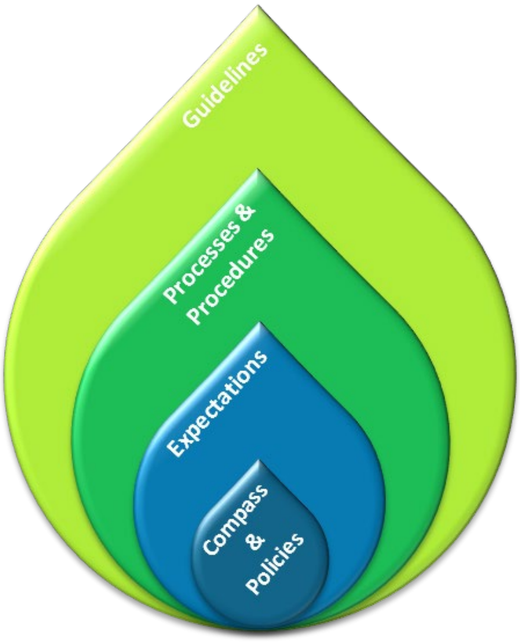

Figure 1-1: The four major elements of the WMS Seed

The WMS is organised within a Business Process Hierarchy based upon Key Business Activities to ensure the system remains independent of organisation structure, is globally applicable and scalable wherever required. These Key Business Activities are grouped into Management, Support, and Value Stream activities as shown in Figure 1-2. The Value Stream activities capture, generate and deliver value through the exploration and production lifecycle. The Management activities influence all areas of the business, while Support activities may influence one or more value stream activities.

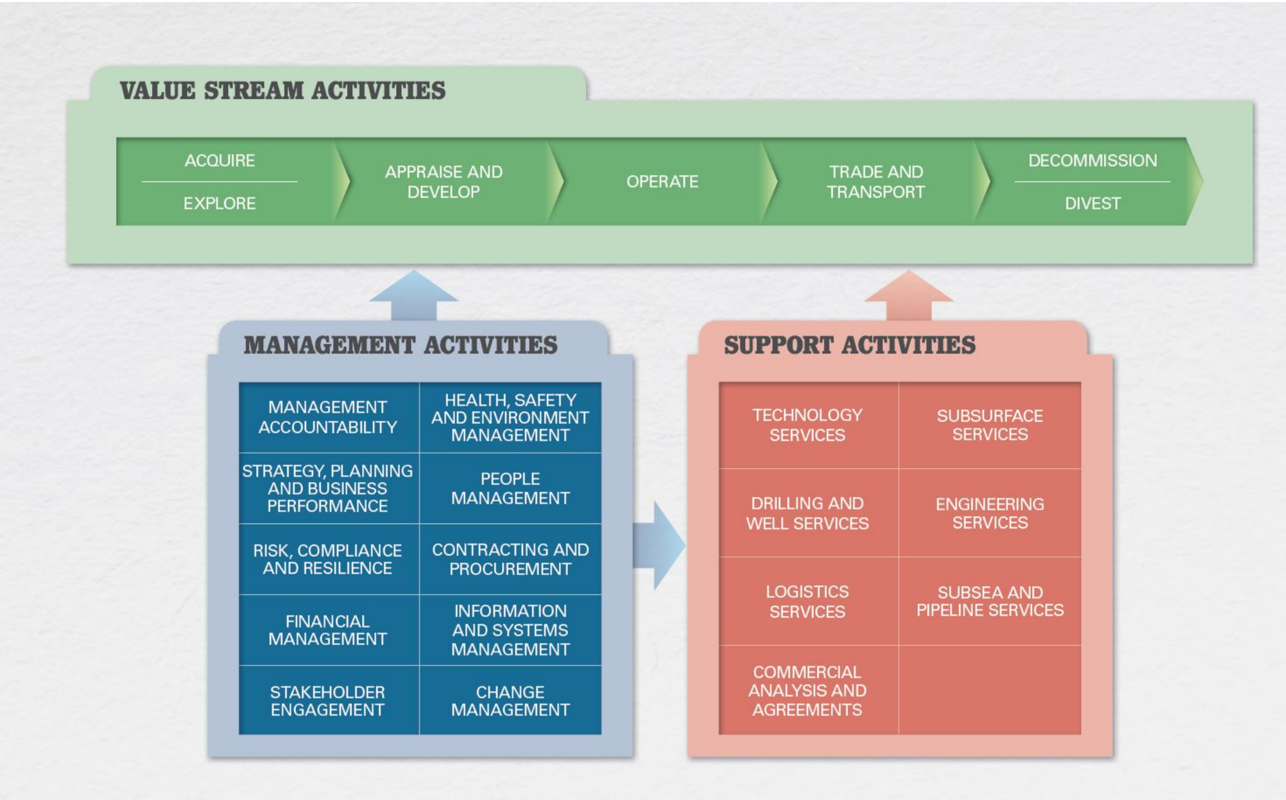

Figure 1-2: The WMS business process hierarchy

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1.9.1 Health, Safety, Environment and Quality Policy

In accordance with Regulation 16(a) of the Environment Regulations, Woodside's Corporate Health, Safety, Environment and Quality Policy is provided in Appendix A of this EP.

1.10 Description of Relevant Requirements

In accordance with Regulation 13(4) of the Environment Regulations, a description of requirements, including legislative requirements, that apply to the activity and are relevant to the management of risks and impacts of the Petroleum Activities Program are detailed in Appendix B. This EP will not be assessed under the WA *Environmental Protection Act 1986* as the activity does not occur on State land or within State Waters.

1.10.1 Applicable Environmental Legislation

The Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) controls exploration and production activities beyond three nautical miles (nm) of the mainland (and islands) to the outer extent of the Australian Exclusive Economic Zone (EEZ) at 200 nm.

The Environment Regulations apply to petroleum activities in Commonwealth Waters, and are administered by NOPSEMA.

The objective of the Environment Regulations is to ensure petroleum activities are:

- carried out in a manner consistent with the principles of ESD
- carried out in a manner by which the environmental impacts and risks of the activity will be reduced to ALARP
- carried out in a manner by which the environmental impacts and risks of the activity will be of an acceptable level.

1.10.1.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is administered by the Commonwealth Department of the Environment and Energy (DoEE). The EPBC Act protects matters of national environmental significance (MNES) across Australia and protects the environment in relation to actions on (or impacting upon) Commonwealth land or waters. When a person proposes to take an action that they believe may need approval under the EPBC Act, they must refer the proposal to the Commonwealth Minister for Environment.

This EP will not be assessed under the EPBC Act as the activity is not a controlled action and does not impact upon MNES or biodiversity.

1.10.2 Australian Marine Parks

Under the EPBC Act, Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of National Parks (DNP) is responsible for managing AMPs (supported by Parks Australia), and is required to publish management plans for them. Other parts of the Commonwealth Government must not perform functions or exercise powers in relation to these parks that are inconsistent with management plans (s.362 of the EPBC Act). Relevant AMPs are described in Section 4.7. The North-west Marine Parks Network Management Plan describes the requirements for management.

Specific zones within the AMPs have been allocated conservation objectives as stated below (International Union for Conservation of Nature [IUCN] Protected Area Category) based on the Australian IUCN reserve management principles outlined in Schedule 8 of the EPBC Regulations 2000:

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- Special Purpose Zone (IUCN category VI): managed to allow specific activities through special purpose management arrangements while conserving ecosystems, habitats and native species. The zone allows or prohibits specific activities.
- Sanctuary Zone (IUCN category Ia): managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible. The zone allows only authorised scientific research and monitoring.
- National Park Zone (IUCN category II): managed to protect and conserve ecosystems, habitats and native species in as natural a state as possible. The zone only allows nonextractive activities unless authorised for research and monitoring.
- Recreational Use Zone (IUCN category IV): managed to allow recreational use, while conserving ecosystems, habitats and native species in as natural a state as possible. The zone allows for recreational fishing, but not commercial fishing.
- Habitat Protection Zone (IUCN category IV): managed to allow activities that do not harm or cause destruction to seafloor habitats, while conserving ecosystems, habitats and native species in as natural a state as possible.
- Multiple Use Zone (IUCN category VI): managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park values.

1.10.3 World Heritage Properties

Australian World Heritage management principles are prescribed in Schedule 5 of the EPBC Regulations 2000. Management principles that are considered relevant to the scope of this EP are provided in Table 1-3.

Table 1-3: Relevant Management Principles under Schedule 5—Australian World Heritage management principles of the EPBC Act.

Number	Principle	Relevant Section of the EP
3	Environmental impact assessment and approval 3.01 This principle applies to the assessment of an action that is likely to have a significant impact on the World Heritage values of a property (whether the action is to occur inside the property or not). 3.02 Before the action is taken, the likely impact of the action on the World Heritage values of the property should be assessed under a statutory environmental impact assessment and approval process. 3.03 The assessment process should: (a) identify the World Heritage values of the property that are likely to be affected by the action; and (b) examine how the World Heritage values of the property might be affected; and (c) provide for adequate opportunity for public consultation. 3.04 An action should not be approved if it would be inconsistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property. 3.05 Approval of the action should be subject to conditions that are necessary to ensure protection, conservation, presentation or transmission to future generations of the World Heritage values of the property. 3.06 The action should be monitored by the authority responsible for giving the approval (or another appropriate authority) and, if necessary, enforcement action should be taken to ensure compliance with the conditions of the approval.	3.01 and 3.02: Assessment of significant impact on World Heritage values is included in Section 6. Principles are met by the submitted EP. 3.03 (a) and (b): World Heritage values are identified in Section 4 and considered in the assessment of impacts and risks for the Petroleum Activity in Section 6. 3.03 (c): Relevant stakeholder consultation and feedback received in relation to impacts and risks to the Ningaloo World Heritage Property are outlined in Section 5. 3.04, 3.05 and 3.06: Principles are considered to be met by the acceptance of this EP.

Note that Section 1 – General Principles and 2 – Management Planning of Schedule 5 are not considered relevant to the scope of this EP and, therefore, have not been included.

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2. ENVIRONMENT PLAN PROCESS

2.1 Overview

This section outlines the process taken by Woodside to prepare this EP, once the activity was defined as a petroleum activity. The process describes the activity, the existing environment, followed by the environmental risk management methodology used to identify, analyse and evaluate risks to meet ALARP levels and acceptability requirements, and develop environmental performance outcomes (EPOs) and environmental performance standards (EPSs). This section also describes Woodside's risk management methodologies as applied to implementation strategies for the activity.

Regulation 13(5) of the Environment Regulations requires the detailing of environmental impacts and risks, and evaluation appropriate to the nature and scale of each impact and risk associated with the Petroleum Activities Program. The objective of the risk assessment process described in this section is to identify risks and associated impacts of an activity, so they can be assessed and appropriate control measures applied to eliminate, control or mitigate the impact/risk to ALARP, and to determine if the impact or risk level is acceptable.

Environmental impacts and risks include those directly and indirectly associated with the Petroleum Activities Program, and include potential emergency and accidental events:

- **Planned activities** have the potential for inherent environmental impacts.
- **Environmental risks** are unplanned events with the potential for environmental impact (termed risk 'consequence').

In this EP:

- potential impacts from planned activities are termed 'impacts.
- 'risks' are associated with unplanned events with the potential for environmental impact should the risk be realised; and such impacts are termed potential 'consequences'.

2.2 Environmental Risk Management Methodology

2.2.1 Woodside Risk Management Process

Woodside recognises that risk is inherent to its business and that effective management of risk is vital to delivering on company objectives, success and continued growth. Woodside is committed to managing all risk in proactively and effectively. The objective of Woodside's risk management system is to provide a consistent process for recognising and managing risks across Woodside's business. Achieving this objective includes ensuring risks consider impacts across these key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural. A copy of Woodside's Risk Management Policy is provided in Appendix A.

The environmental risk management methodology used in this EP is based on Woodside's Risk Management Procedure (Woodside Doc No. WM0000PG10055394). This procedure aligns to industry standards, such as international standard ISO 31000:2009. Woodside's WMS risk management procedures, guidelines and tools provide guidance of specific techniques for managing risk, tailored for particular areas of risk within certain business processes. Procedures applied for environmental risk management include:

- Health, Safety and Environment Management Procedure (Woodside Doc No. WM0000MG10347354)
- Impact Assessment Procedure (Woodside Doc No. WM0000PG10996761)
- Process Safety Management Procedure (Woodside Doc No. WM0000PG9905457).

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The risk management methodology provides a framework to demonstrate that risks and impacts are continually identified, reduced to ALARP and assessed to be at an acceptable level, as required by the Environment Regulations. The key steps of Woodside's Risk Management Process are shown in Figure 2-1. A description of each step and how it is applied to the scopes of this activity is provided in Sections 2.2 to 2.11.

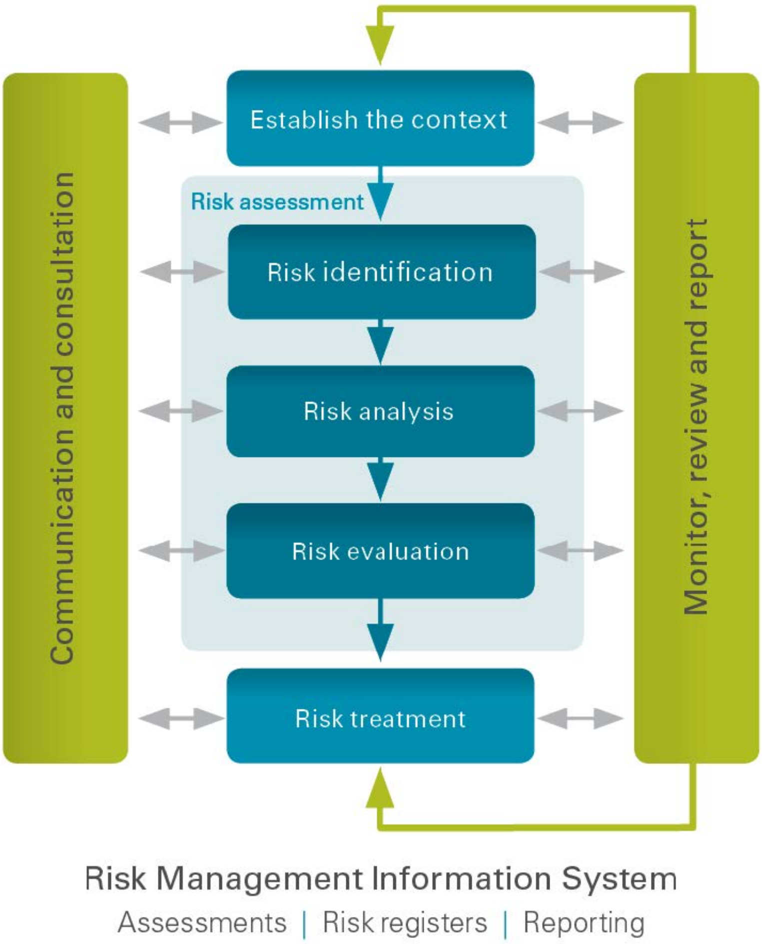

Figure 2-1: Woodside's risk management process

2.2.2 Health, Safety and Environment Management Procedure

The Health, Safety and Environment Management Procedure (Woodside Doc No. WM0000MG10347354) provides the structure for managing health, safety and environment (HSE) risks and impacts across Woodside, defines the decision authorities for company-wide HSE management activities and deliverables, and supports continuous improvement in HSE management.

2.2.3 Impact Assessment Procedure

To support effective environmental risk assessment, Woodside's Impact Assessment Procedure (Woodside Doc No. WM0000PG10996761) (Figure 2-2) provides the steps to meet the required environment, health and social standards by ensuring impact assessments are undertaken appropriate to the nature and scale of the activity, the regulatory context, the receiving environment, interests, concerns and rights of stakeholders, and the applicable framework of standards and practices.

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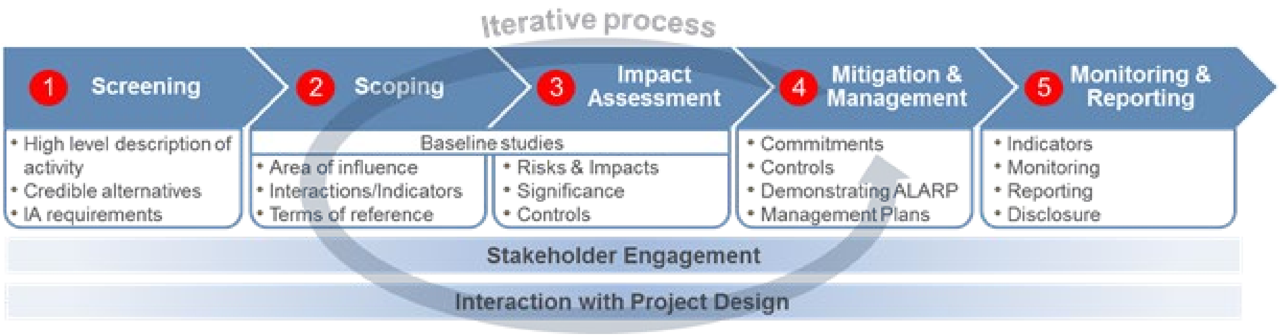

Figure 2-2: Woodside's impact assessment process

2.2.4 Process Safety Management Procedure and Process Safety Risk Assessment Procedure

Due to the nature and scale of petroleum activities, Woodside's Process Safety Management Procedure (Woodside Doc No. WM0000PG9905457) establishes Woodside's framework for Process Safety Management (Section 7.1.2). This framework includes the Process Safety Risk Assessment Procedure (Woodside Doc No. WM0000PG10137463) (PSRA). The PSRA is a key part of Woodside's process safety management framework for managing the integrity of systems and processes that handle hazardous substances over the exploration and production lifecycle. The PSRA sets out methods to ensure that process safety risks are understood and controlled, including that all process safety hazards are systematically identified, assessed and treated so that the associated risks are reduced to a level that is tolerable and ALARP.

2.3 Environment Plan Process

Figure 2-3 illustrates the EP development process. Each element of this process is discussed further in Sections 2.5 to 2.10.

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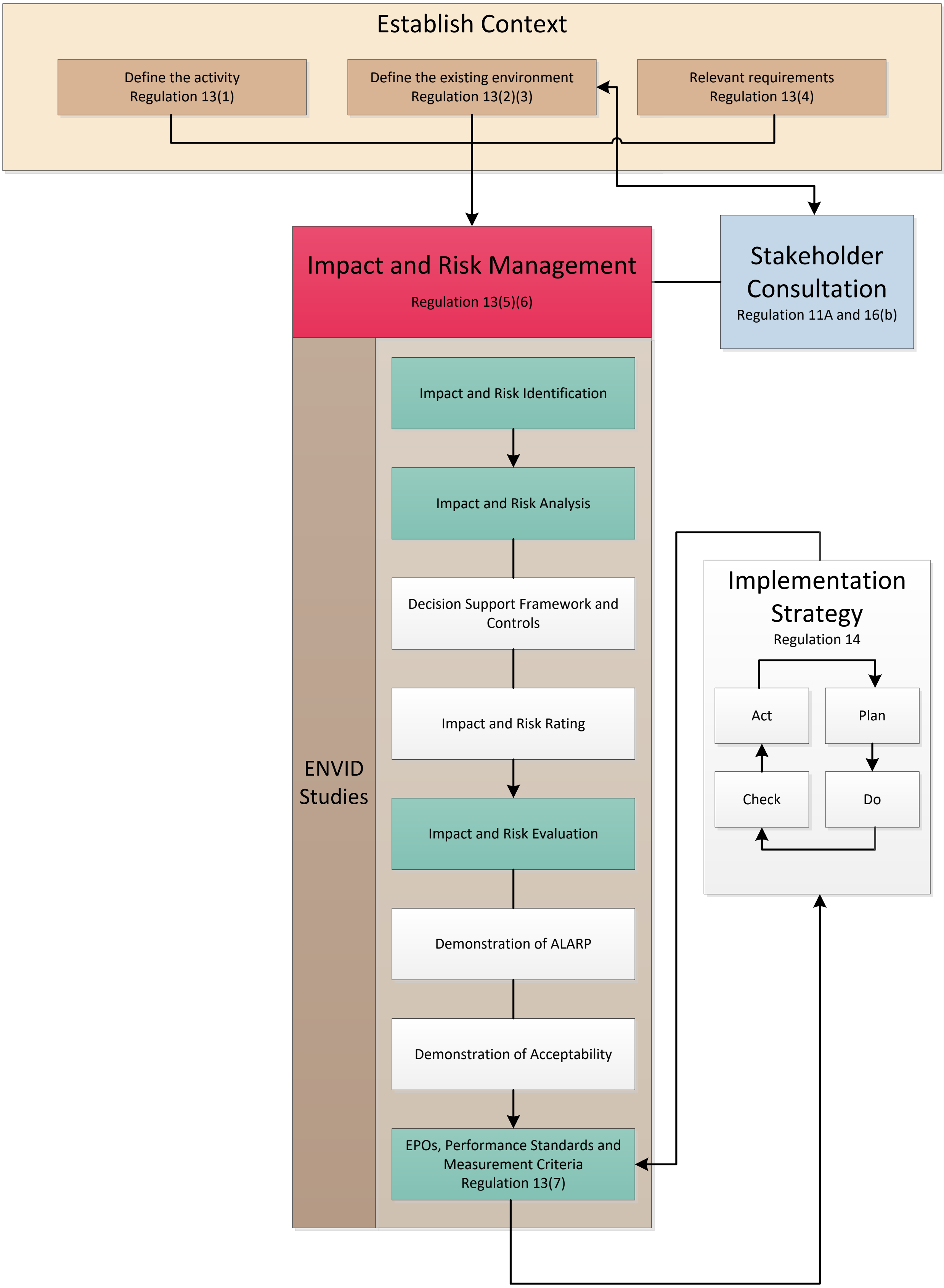

Figure 2-3: Environment Plan development process

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2.4 Establish the Context

2.4.1 Define the Activity

This first stage involves evaluating whether the activity meets the definition of a 'petroleum activity' as defined in the Environment Regulations. The activity is described in relation to:

- the location
- what is to be undertaken, including general details such as the construction and layout of the facility
- how it is planned to be undertaken, including outlining operational details of the activity and proposed timeframes.

The 'what' and 'how' are described in the context of 'environmental aspects'[1] to inform the risk and impact assessment for planned (routine and non-routine) and unplanned (accidents/incidents/emergency conditions) activities.

The activity is described in Section 3 and is referred to as the Petroleum Activities Program.

2.4.2 Define the Existing Environment

The context of the existing environment is described and determined by considering the nature and scale of the activity (size, type, timing, duration, complexity, and intensity of the activity), as described in Section 3. The purpose is to describe the existing environment that may be impacted by the activity, directly or indirectly, by planned or unplanned[2] events.

The Existing Environment (Section 4) is structured into subsections defining the physical, biological, socioeconomic and cultural attributes of the area of interest, in accordance with the definition of environment in Regulation 4(a) of the Environment Regulations. These subsections make particular reference to:

- The environmental, and social and cultural consequences as defined by Woodside (refer to Table 2-1), which address key physical and biological attributes, as well as social and cultural values of the existing environment. These consequence definitions are applied to the impact and risk analysis (refer Section 2.2) and rated for all planned and unplanned activities. Additional detail is provided for unplanned hydrocarbon spill risk evaluation.
- EPBC Act MNES including listed threatened species and ecological communities and listed migratory species. Defining the spatial extent of the existing environment is guided by the nature and scale of the Petroleum Activities Program (and associated sources of environmental risk). This considers the Operational Area and wider environment that may be affected (EMBA), as determined by the hydrocarbon spill risk assessments presented in Section 6.8. MNES, as defined within the EPBC Act, are addressed through Woodside's impact and risk assessment (Section 6).
- Relevant values and sensitivities, which may include world or national heritage listed areas, listed threatened species or ecological communities, listed migratory species, or sensitive values.

By grouping potentially impacted environmental values by aspect (as presented in Table 2-1), the presentation of information about the receiving environment is standardised. This information is then

[1] An environmental aspect is an element of the activity that can interact with the environment.

[2] For each source of risk, the credible worst-case scenario in conjunction with impact thresholds is used to determine the spatial extent of the EMBA. The worst-case unplanned event is considered to be an unplanned hydrocarbon release, further defined for each activity through the risk assessment process. Interpretation of stochastic oil spill modelling determines the EMBA for the release, which defines the spatial scale of the environment that may be potentially impacted by the Petroleum Activities Program, which provides context to the 'nature and scale' of the existing environment.

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consistently applied to the risk evaluation section to provide a robust approach to the overall environmental risk evaluation and its documentation in the EP.

Table 2-1: Example of the environment values potentially impacted which are assessed within the EP

Environmental Value Potentially Impacted Regulations 13(2)(3)						
Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl. Odour)	Ecosystems/ Habitats	Species	Socioeconomic

2.4.3 Relevant Requirements

The relevant requirements in the context of legislation, other environmental approval requirements, conditions and standards that apply to the Petroleum Activities Program are identified and reviewed, and are presented in Appendix B.

The Corporate Health, Safety, Environment and Quality Policy is presented in Appendix A.

2.5 Impact and Risk Identification

Relevant environmental aspects and hazards were identified that support the process to define environmental impacts and risks associated with an activity.

The environmental impact and risk assessment presented in this EP has been informed by recent and historic hazard and environment identification studies (e.g. HAZID/ENVID), PSRA processes, reviews, and desktop studies associated with the Petroleum Activities Program. Impacts, risks and potential consequences were identified based on planned and potential interaction with the activity (based on the description in Section 3), the existing environment (Section 4) and the outcomes of Woodside's stakeholder engagement process (Section 5). The environmental outputs of applicable risk and impact workshops and associated studies are referred to as ENVID in this EP.

The ENVID was undertaken by multidisciplinary teams comprising relevant operational and environmental personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks and impacts were identified and their potential environmental consequences assessed. Impacts and risks were identified during the ENVID for both planned (routine and non-routine) activities and unplanned (accidents/incidents/emergency conditions) events. During this process, risks identified as not applicable (not credible) were removed from the assessment.

The impact and risk information were classified, evaluated and tabulated for each planned activity and unplanned event. Environmental impacts and risk were recorded in an environmental impacts and risk register. The output of the ENVID is used to present the risk assessment and form the basis of performance outcomes, standards, and measurement criteria. This information is presented in Section 6, following the format presented in Table 2-2.

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Table 2-2: Example of layout of identification of risks and impacts in relation to risk sources

Impacts and Risks Evaluation Summary													
Source of Risk	Environmental Value Potentially Impacted							Evaluation					
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/Habitat	Species	Socioeconomic	Decision Type	Consequence / Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability
Summary of source of impact/risk													

2.6 Impact and Risk Analysis

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

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

- identify the decision type in accordance with the decision support framework
- identify appropriate control measures (preventive and mitigation) aligned with the decision type
- assess the risk rating.

2.6.1 Decision Support Framework

To support the risk assessment process and Woodside's determination of acceptability (Section 2.8.2), Woodside's HSE risk management procedures include the use of a decision support framework based on principles set out in the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This concept was applied during the ENVID, or equivalent processes during historical design decisions, to determine the level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk is acceptable and ALARP (Figure 2-4). Application of the decision support framework confirms:

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

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

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

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2.6.1.1 Decision Type A

Decision Type A risks and impacts are well understood and established practice; they are generally recognised as good industry practice and are often embodied in legislation, codes and standards, and use professional judgment.

2.6.1.2 Decision Type B

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

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

2.6.1.3 Decision Type C

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

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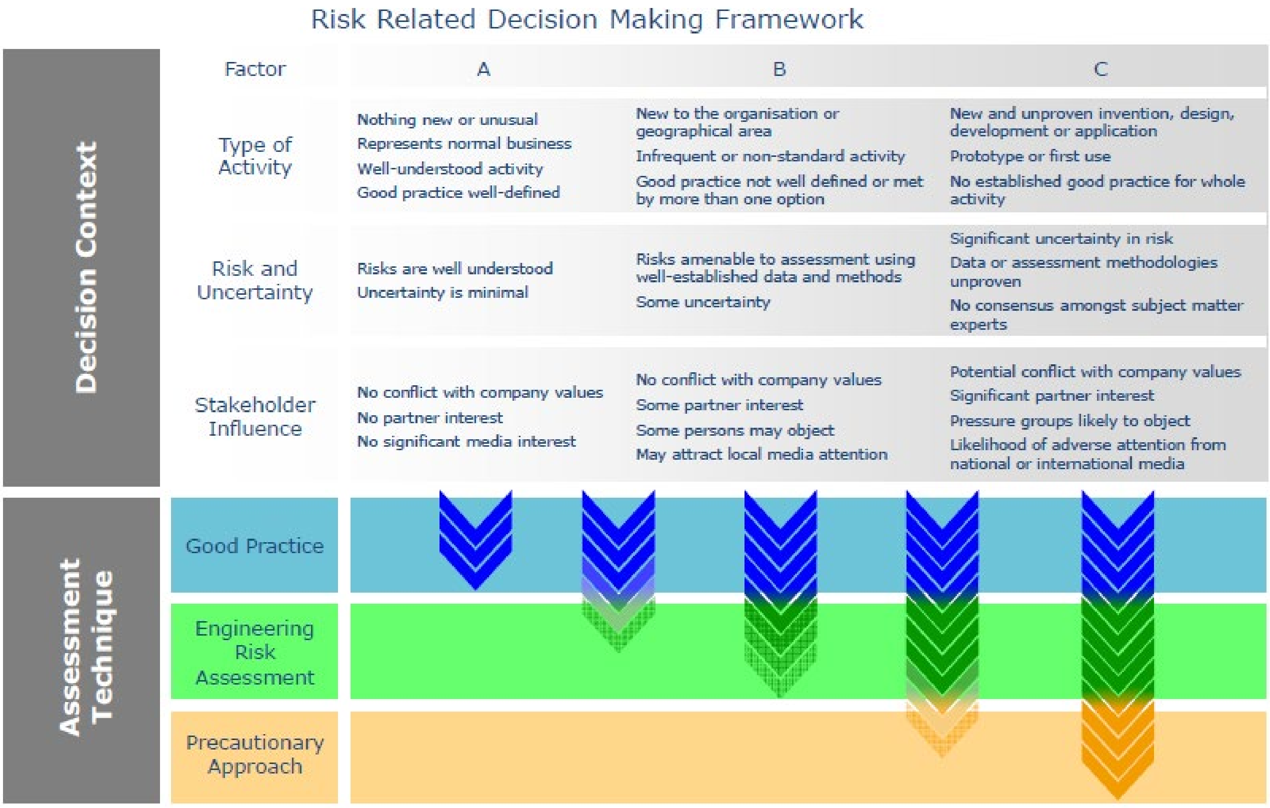

Figure 2-4: Risk-related decision-making framework

Source: Oil and Gas UK (2014)

2.6.1.4 Decision Support Framework Tools

These framework tools are applied, as appropriate, to help identify control measures based on the decision type described above:

- **Legislation, Codes and Standards (LCS)** – identifies the requirements of legislation, codes and standards that are to be complied with for the activity.
- **Good Industry Practice (GP)** – identifies further engineering control standards and guidelines that may be applied by Woodside above that required to meet the LCS.
- **Professional Judgement (PJ)** – uses relevant personnel with the knowledge and experience to identify alternative controls. Woodside applies the hierarchy of control as part of the risk assessment to identify any alternative measures to control the risk.
- **Risk-based Analysis (RBA)** – assesses the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost–benefit analysis to support the selection of control measures identified during the risk assessment process.
- **Company Values (CV)** – identifies values identified in Woodside's code of conduct, policies and the Woodside Compass. Views, concerns and perceptions are to be considered from internal Woodside stakeholders directly affected by the planned impact or potential risk.
- **Societal Values (SV)** – identifies the views, concerns and perceptions of relevant stakeholders and addresses relevant stakeholder views, concerns and perceptions.

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Decision Calibration

To determine that the alternatives selected and the control measures applied are suitable, these tools may be used for calibration (i.e. checking) where required:

- **LCS/Verification of Predictions** – Verification of compliance with applicable LCS and/or good industry practice.
- **Peer Review** – Independent peer review of PJs, supported by RBA, where appropriate.
- **Benchmarking** – Where appropriate, benchmarking against a similar facility or activity type or situation that has been deemed to represent acceptable risk.
- **Internal Stakeholder Consultation** – Consultation undertaken within Woodside to inform the decision and verify company values are met.
- **External Stakeholder Consultation** – Consultation undertaken to inform the decision and verify societal values are considered.

Where appropriate, additional calibration tools may be selected specific to the decision type and the activity.

2.6.2 Control Measures (Hierarchy of Controls)

Risk reduction measures are prioritised and categorised in accordance with the hierarchy of controls, where risk reduction measures at the top of the hierarchy take precedence over risk reduction measures further down:

- **Elimination** of the risk by removing the hazard.
- **Substitution** of a hazard with a less hazardous one.
- **Engineering Controls** include design measures to prevent or reduce the frequency of the risk event, or detect or control the risk event (limiting the magnitude, intensity and duration) such as:
  - Prevention: design measures that reduce the likelihood of a hazardous event occurring
  - Detection: design measures that facilitate early detection of a hazardous event
  - Control: design measures that limit the extent/escalation potential of a hazardous event
  - Mitigation: design measures that protect the environment if a hazardous event occurs
  - Response Equipment: design measures or safeguards that enable clean-up/response after a hazardous event occurs.
- **Procedures and Administration** includes management systems and work instructions used to prevent or mitigate environmental exposure to hazards.
- **Emergency Response and Contingency Planning** includes methods to enable recovery from the impact of an event (e.g. protection barriers deployed near the sensitive receptor).

2.6.3 Impact and Risk Classification

Environmental impacts and risks are assessed to determine the potential impact significance/consequence. The impact significance/consequence considers the magnitude of the impact or risk and the sensitivity of the potentially impacted receptor (represented by Figure 2-5).

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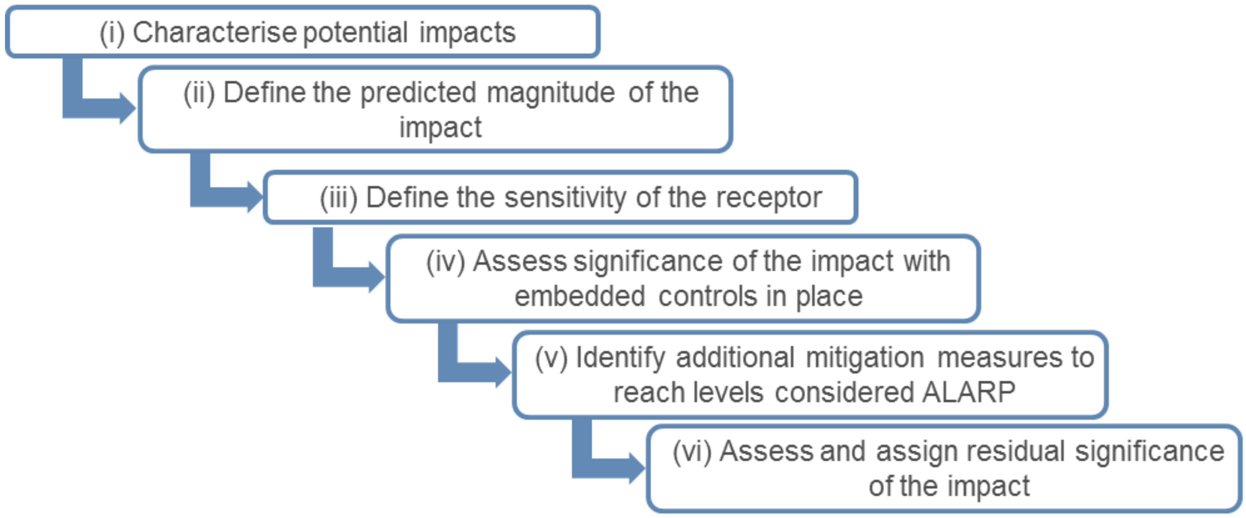

Figure 2-5: Environmental risk and impact analysis

Impacts are classified in accordance with the consequence (Table 2-3) outlined in Woodside's Risk Management Procedure and Risk Matrix (Figure 2-6). Risks are assessed qualitatively and/or quantitatively in terms of both likelihood and consequence in accordance with this matrix.

The impact and risk information, including classification and evaluation information as shown in the example (Table 2-2), are tabulated for each planned activity and unplanned event.

Table 2-3: Woodside risk matrix (Environment and Social and Cultural) consequence descriptions

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

2.6.3.1 Risk Rating Process

The risk rating process assigns a level of risk to each risk event, measured in terms of consequence and likelihood. The assigned risk rating is determined with controls in place; therefore, the risk rating is determined after identifying the decision type and appropriate control measures.

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The risk rating process considers the potential environmental consequences and, where applicable, the social and cultural consequences of the risk. The risk ratings are assigned using the Woodside Risk Matrix (refer to Figure 2-6).

The risk rating process is done using the steps described in the subsections below.

Select the Consequence Level

Determine the worst-case credible consequence (Table 2-3) associated with the selected event, assuming all controls (preventive and mitigative) are absent or have failed. If more than one potential consequence applies, select the highest severity consequence level.

Select the Likelihood Level

Determine the description that best fits the chance of the selected consequence occurring, assuming reasonable effectiveness of the prevention and mitigation controls (Table 2-4).

Table 2-4: Woodside risk matrix likelihood levels

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

Calculate the Risk Rating

The risk rating is derived from the consequence and likelihood levels above, in accordance with the Woodside Risk Matrix shown in Figure 2-6. A likelihood and risk rating are only applied to environmental risks, not environmental impacts from planned activities.

This risk rating is used as an input into the risk evaluation process and ultimately for prioritising further risk reduction measures. Once each risk is treated to ALARP, the risk rating articulates the ALARP baseline risk as an output of the ENVID studies.

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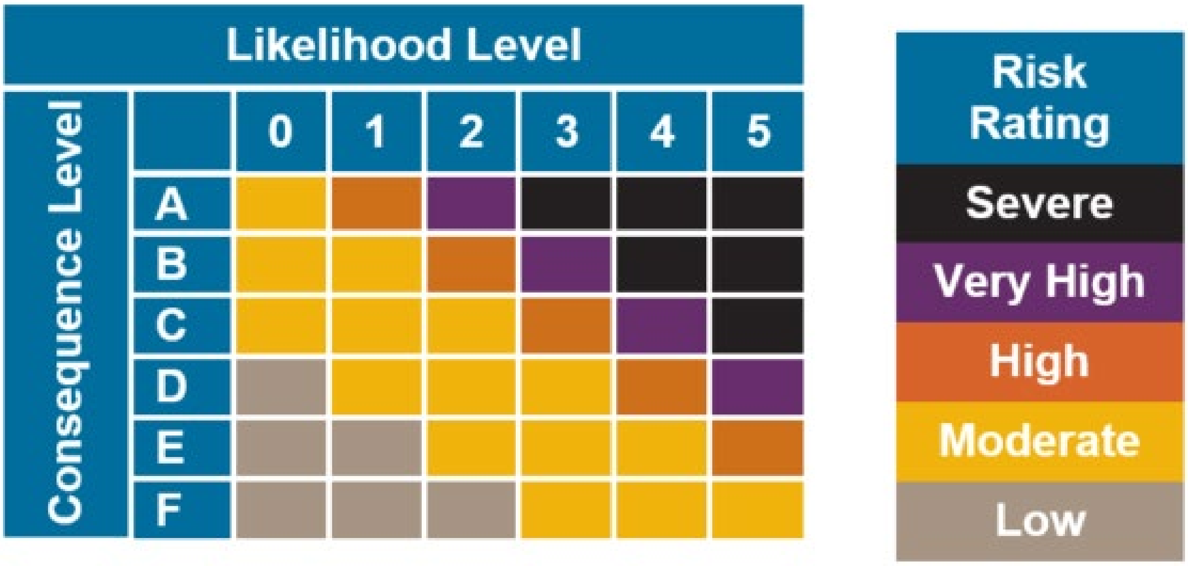

Figure 2-6: Woodside risk matrix – risk level

To support ongoing risk management (as a key component of Woodside's Process Safety Management Framework – refer to the implementation strategy in Section 7), Woodside uses the concept of 'current risk' and applies a Current Risk Rating to indicate the current or 'live' level of risk, considering controls that are currently in place and effective on a day-to-day basis. The Current Risk Rating is effective in articulating potential divergence from baseline risk, such as if certain controls fail or could potentially be compromised. Current Risk Ratings aid in communicating and making visible the risk events and ensures the continual management of risk to ALARP by identifying risk reduction measures and assessing acceptability.

2.7 Classification and Analysis of Major Environment Events

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

Woodside defines a MEE as an event with potential environment, reputation (pertaining to environment events), social or cultural consequences of level B or higher as per Woodside's Risk Matrix (Figure 2-6). MEEs are evaluated against credible worst-case scenarios that may occur when all controls are absent or have failed.

2.7.1 MEE Identification

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

Although these risks are screened out, all risks identified in this EP (including MEEs), are evaluated for ALARP and acceptability using the methodology described in Section 2.8.

2.7.2 MEE Classification

A standard naming convention has been established for MEEs; this is based around ensuring the MEE titles reflect the cause of the event, e.g. 'subsea system loss of containment', rather than the

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event itself, e.g. significant hydrocarbon spill to the marine environment. The MEEs are assigned a unique identification code, e.g. MEE-01, MEE-02, etc.

2.7.3 Bowtie Analysis

MEEs are subject to more detailed analysis using the bowtie risk assessment technique, which illustrates outcomes and controls in place to prevent the 'top event' or mitigate the consequences. The key drivers for adopting the bowtie technique for MEEs are that it:

- identifies the controls (prevention and mitigation barriers) necessary to ensure the risk is acceptable and ALARP
- supports the process of demonstrating ALARP (described in Section 2.8.1)
- enables verification of and linking to the relevant sections of the WMS that supports barriers
- improves the capacity for lessons learnt and incident prevention by being able to directly relate causes of an incident to those controls that failed
- ensures greater visibility and granularity in the assessment process and enables complex risk scenarios to be presented in an easy to understand format.

The bowtie technique (an example bowtie diagram is shown in Figure 2-7) shows the relationships between the 'Causes' that may lead to a particular unwanted event ('Top Event'), together with the range of potential escalation paths that can lead to a variety of 'Outcomes' (or consequences). A bowtie also shows the preventive barriers that may prevent a Top Event from occurring specific to each Cause, and the mitigation barriers in place to limit the potential effects once the Top Event has been realised, specific to each credible MEE Outcome.

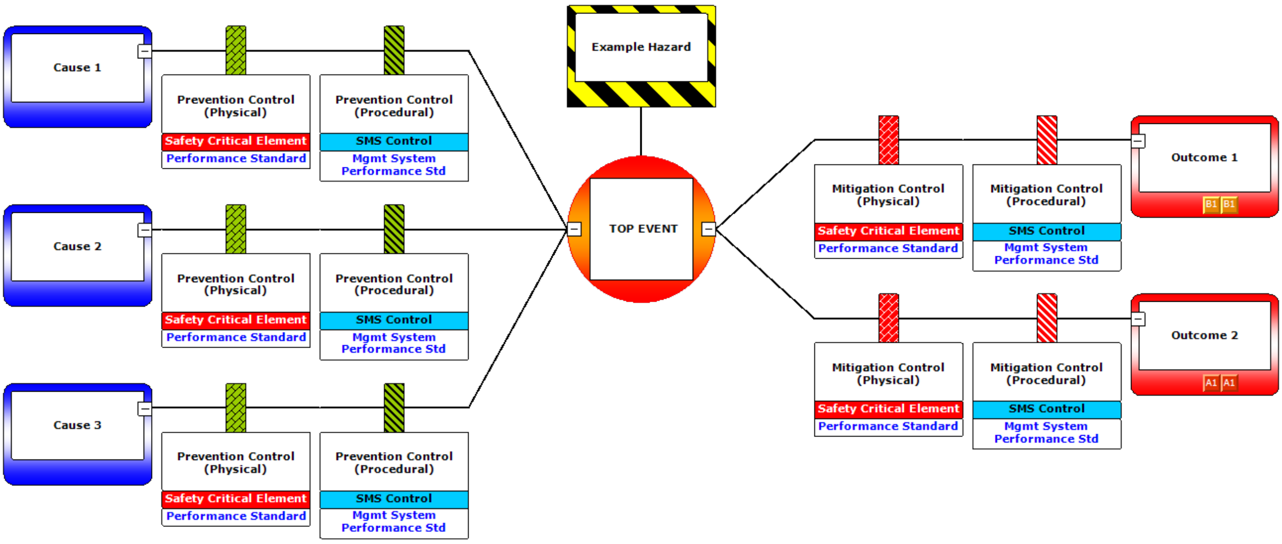

Figure 2-7: Example of bowtie diagram structure

2.7.4 MEE Register

A MEE Register is prepared for each production facility after completing bowtie diagrams. The purpose of the MEE Register is to record the MEE identification process, groupings, bowtie diagrams and datasheets in a consolidated format. Datasheets are prepared for each MEE, which summarise the hazard description, hazard management, emergency response, ALARP summary and a list of critical barriers identified on the bowties (known as Safety and Environment Critical Elements [SCEs]).

Potential common causes that contribute to MAEs/MEEs, or that can result in failure or degradation of the controls in place to protect against MAEs/MEEs, include some generic mechanisms of SCE

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failure and generic human error. These are represented in bowties applicable to multiple MEEs. The generic SCE failure bowtie illustrates the causes, outcomes and controls in place to manage potential failure mechanisms. Human errors are managed via the WMS. The Generic Human Error bowtie is included in the MEE Register.

2.7.5 Safety and Environment Critical Elements (SCEs) and SCE Technical Performance Standards

Woodside identifies and manages SCE technical and management system performance standards in accordance with Process Safety Management Procedures, Risk Management Procedures and Change Management Procedures (further described in the implementation strategy in Section 7). SCEs are identified for MAEs and MEEs. An SCE is a hardware control, the failure of which could cause or contribute substantially to, or the purpose of which is to prevent or limit the effect of a MAE, MEE or Process Safety Event. In addition, Woodside defines Safety and Environment Critical Equipment (SCQ) as an item of equipment or structure forming part of a hardware SCE that supports the SCE in achieving the safety function[3].

Once each SCE is selected, technical performance requirements are developed in accordance with the Safety and Environment Critical Element (SCE) Management Procedure (Woodside Doc No. WM1040PF9809289) and form the SCE technical performance standards. These standards are a statement of the performance required of an SCE (e.g. functionality, availability, reliability, survivability). They are used to establish agreed assurance tasks for each SCE, support the management of operations within acceptable safety and/or environment risk levels, and ensure continuous management of risk to ALARP. An assurance task is an activity carried out by the operator to confirm that the SCE meets, or will meet, its SCE Performance Standard. Examples of assurance tasks include inspection routines, maintenance activities, test routines, instrumentation calibration, and reliability monitoring.

SCE Technical Performance Standards do not always align directly with EPSs. They are used in conjunction with the WMS to identify and treat potential step-outs from expected controls performance or integrity envelopes and ensure SCE performance can be optimised. Woodside's HSE Event Reporting Guideline (Woodside Doc No. WM0000MG9905230) describes the process for identifying 'Damage to SCEs', which is an SCE failure presenting a risk level that requires Immediate Control Actions be put in place to manage increased current risk (see Section 7.1.5). For applicable SCEs, 'Damage to SCE' failures represent scenarios that may fail to achieve an EPS presented in this EP.

Section 6.8.2 of this EP presents the results of the MEE classification and analysis for the Okha facility. More detail on the SCE and Performance Standards process, and the interrelationships to other parts of the SCE Management Procedures, is described in Section 7.1.5.

2.7.6 Safety-critical Management System Barriers

For each MEE, Safety-critical Management System specific measures are also identified. These are management system components (generally WMS processes) that are key barriers to, or measures for, managing MEEs.

2.8 Impact and Risk Evaluation

Environmental impacts and risks cover a wider range of issues, differing species, persistence, reversibility, resilience, cumulative effects, and variability in severity than safety risks. Determining the degree of environmental risk, and the corresponding threshold for whether a risk/impact has

[3] *Note: Not all individual equipment items that comprise a SCE are safety-critical.*

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been reduced to ALARP and is acceptable, is evaluated to a level appropriate to the nature and scale of each impact or risk. Evaluation includes considering the:

- Decision Type
- principles of ESD – as defined under the EPBC Act
- internal context – ensuring the proposed controls and risk level are consistent with Woodside policies, procedures and standards (Section 7 and Appendix A)
- external context – the environment consequence (Section 6) and stakeholder acceptability (Section 5)
- other requirements – ensuring the proposed controls and risk level are consistent with national and international standards, laws and policies.

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

2.8.1 Demonstration of ALARP

The descriptions in Table 2-5 articulate how Woodside demonstrates that different risks, impacts and Decision Types identified within the EP are ALARP.

Table 2-5: Summary of Woodside's criteria for ALARP demonstration

Risk	Impact	Decision Type
Low and Moderate (below C level consequence)	**Negligible, Slight, or Minor (D, E or F)**	**A**
Woodside demonstrates these risks, impacts and decision types are reduced to ALARP if: • identified controls meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines, or • further effort towards impact/risk reduction (beyond using opportunistic measures) is not reasonably practicable without sacrifices that are grossly disproportionate to the benefit gained.		
High, Very High or Severe (C+ consequence risks)	**Moderate and above (D, E or F)**	**B and C**
Woodside demonstrates these higher-order risks, impacts and decision types are reduced to ALARP where it can be shown good industry practice and RBA have been employed, if legislative requirements are met, societal concerns are accounted for, and the alternative control measures are grossly disproportionate to the benefit gained.		

2.8.2 Demonstration of Acceptability

The descriptions in Table 2-6 articulate how Woodside demonstrates how different risks, impacts and Decision Types identified within the EP are Acceptable (refer to Figure 2-8 for a visual representation against Woodside's risk matrix).

Table 2-6: Summary of Woodside's criteria for acceptability

Risk	Impact	Decision Type
Low and Moderate	**Negligible, Slight, or Minor (D, E or F)**	**A**
Woodside demonstrates these risks, impacts and decision types are 'Broadly Acceptable' if they meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines. Further effort towards risk reduction (beyond using opportunistic measures) is not reasonably practicable without sacrifices that are grossly disproportionate to the benefit gained.		

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Risk	Impact	Decision Type
High, Very High or Severe	**Moderate and above (D, E or F)**	**B and C**

Woodside demonstrates these higher-order risks, impacts and decision types are 'Acceptable if ALARP' where it can be shown good industry practice and RBA have been employed, if legislative requirements are met and societal concerns are accounted for, and the alternative control measures are grossly disproportionate to the benefit gained.

In undertaking this process for Moderate and High current risks, Woodside evaluates the:

- principles of ESD – as defined under the EPBC Act
- internal context – ensuring the proposed controls and consequence/risk level are consistent with Woodside policies, procedures and standards
- external context – considering the environment consequence (Section 6)
- stakeholder acceptability (Section 7)
- other requirements – ensuring the proposed controls and consequence/risk level are consistent with national and international standards, laws and policies.

Additionally, Very High and Severe risks require 'Escalated Investigation' and mitigation to reduce the risk to a lower and more acceptable level. If, after further investigation, the risk remains in the Very High or Severe category, the risk requires appropriate business engagement to accept the risk in accordance with Woodside's Risk Management Procedure. This includes due consideration of regulatory requirements.

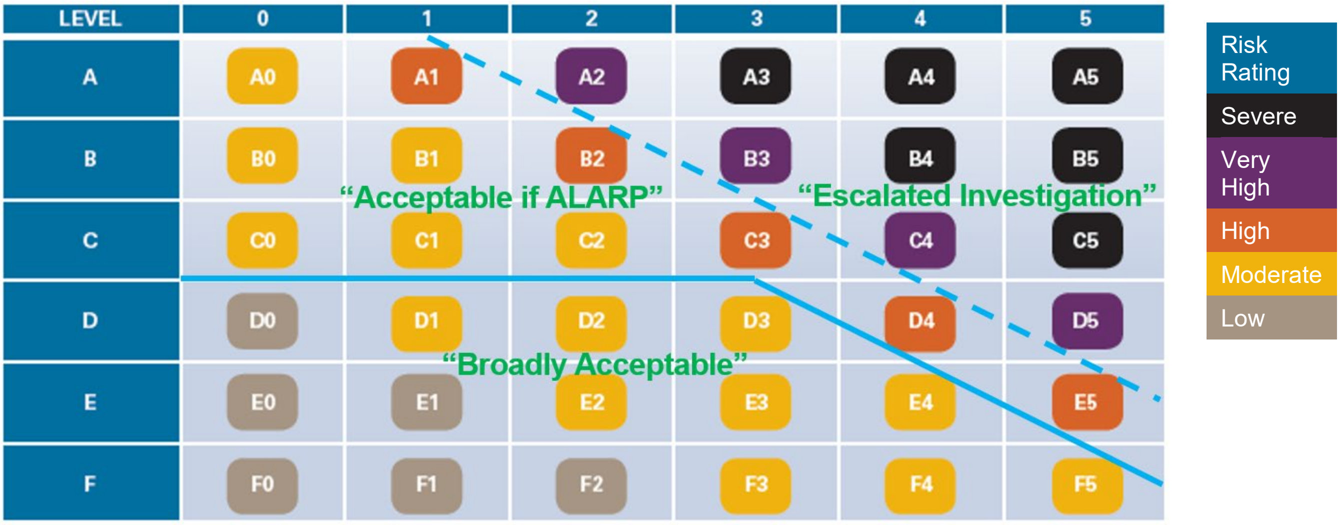

Figure 2-8: Environmental risk evaluation

2.9 Environmental Performance Outcomes, Environmental Performance Standards, and Measurement Criteria

EPOs, EPSs and measurement criteria (MC) are defined to address the potential environmental impacts and risks. These are explored in Section 6.

2.10 Implement, Monitor, Review and Reporting

An implementation strategy for the Petroleum Activities Program describes the specific measures and arrangements to be implemented for the duration of the program. The strategy is based on the principles of AS/NZS ISO 14001 Environmental Management Systems, and demonstrates:

- control measures are effective in reducing the environmental impacts and risks of the Petroleum Activities Program to ALARP and Acceptable levels
- EPOs and EPSs set out in the EP are met through monitoring, recording, auditing, managing non-conformance, and reviewing

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- all environmental impacts and risks of the Petroleum Activities Program are periodically reviewed in accordance with Woodside's risk management procedures
- roles and responsibilities are clearly defined, and personnel are competent and appropriately trained to implement the requirements set out in this EP, including in emergencies or potential emergencies
- arrangements are in place for oil pollution emergencies, to respond to and monitor impacts
- environmental reporting requirements are met, including 'reportable incidents'
- appropriate stakeholder consultation is undertaken throughout the activity.

The implementation strategy is presented in Section 7.

2.11 Stakeholder Consultation

A stakeholder assessment is undertaken to identify relevant people (as defined under Regulation 11A of the Environment Regulations) to whom an activity update is issued electronically; reasonable consultation periods are included. Further details and information is provided to any stakeholder if requested.

A summary and assessment of each stakeholder response is undertaken and a response, where appropriate, is provided by Woodside.

The stakeholder consultation, along with the process for ongoing engagement and consultation throughout the activity, is presented in Section 5. A copy of the full text correspondence with relevant people is provided in Appendix F.

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3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

This section has been prepared in accordance with Regulation 13(1) of the Environment Regulations and describes the activities to be undertaken as part of the Petroleum Activities Program under this EP. It includes the location of the activity, general details of the facility's layout, the operational details of the activity, and additional information relevant to consideration of environmental risks and impacts.

Okha is a standalone FPSO. It is designed to separate, process, store, and offload oil and export gas from the CWLH fields. The FPSO offtakes oil to trading tankers, and gas is transported via the WC GEL and can be directed to either trunkline. The production system comprises subsea wells and infrastructure (e.g. wellheads, Xmas trees, manifolds, umbilicals, flowlines, and risers), an RTM, the FPSO, and the WC GEL.

3.2 Location

The Okha FPSO and associated infrastructure (Table 3-1) is located in Production Licence Areas WA-9-L, WA-11-L, and WA-16-L, and is situated in 80 m of water over the central area of the Wanaea field. The WC GEL operates under Pipeline Licence WA-4-PL, and varies in depth from 80 m at its eastern end (at Okha) to 125 m at its western end (32 km west of the Okha FPSO; within the Operational Area).

Two other temporarily abandoned exploration wells (Goodwyn-6 and Angel-1) are located in nearby titles closer to the Goodwyn (WA-5-L) and Angel (WA-3-L) platforms.

The Okha FPSO and associated infrastructure is marked on nautical maps and is surrounded by a 500 m petroleum safety zone (PSZ). The coordinates of the Okha FPSO and associated infrastructure are listed in Table 3-1.

Table 3-1: Okha FPSO and associated infrastructure locations and petroleum permits

Infrastructure	Water Depth (Approx. m LAT)	Latitude (WGS84)	Longitude (WGS84)	Petroleum Titles
Okha FPSO	80	19° 35′ 20.695″S	116° 26′ 48.651″E	WA-11-L
East end of Okha WC GEL (Okha facility)	76	19°35′20.92″S	116°26′33.75″E	WA-4-PL
West end of Okha WC GEL (NRC facility)	125	19°35′07.14″S	116°08′21.88″E	WA-4-PL
Cossack-4H (CK4)	81	19° 33′ 22.909″ S	116° 29′ 35.754″ E	WA-9-L
Wanaea-3 (WA3)	83	19° 34′ 41.837″ S	116° 27′ 0.216″ E	WA-9-L
Wanaea-8 (WA8)	83	19° 34′ 40.796″ S	116° 26′ 59.438″ E	WA-9-L
Wanaea-6 (WA6)	82	19° 34′ 41.849″ S	116° 26′ 58.559″ E	WA-9-L
Wanaea-1ST1 (WA1)	82	19° 35′ 30.385″ S	116° 26′ 7.466″ E	WA-11-L
Wanaea-2A (WA2)	79	19° 36′ 44.588″ S	116° 24′ 46.054″ E	WA-11-L
Wanaea-7ST1 (WA7)	82	19° 35′ 31.586″ S	116° 26′ 6.622″ E	WA-11-L
Wanaea-9ST1 (WA9)	80	19° 36′ 45.783″ S	116° 24′ 45.838″ E	WA-11-L
Wanaea-11A (WA11)	81	19° 35′ 32.159″ S	116° 26′ 8.927″ E	WA-11-L
Lambert-4 (LA4)	128	19° 26′ 57.820″ S	116° 29′ 15.427″ E	WA-16-L
Lambert-6 (LH6)	128	19° 26′ 56.873″ S	116° 29′ 16.854″ E	WA-16-L
Lambert-7 (LA7)	129	19° 26′ 57.974″ S	116° 29′ 18.617″ E	WA-16-L

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Infrastructure	Water Depth (Approx. m LAT)	Latitude (WGS84)	Longitude (WGS84)	Petroleum Titles
Lambert-3 (LH3)	128	19° 26′ 58.469″ S	116° 29′ 16.227″ E	WA-16-L
Cossack-1[1]	84	19°33′17.129″S	116°29′50.555″E	WA-9-L
Lambert 5ST1[1]	118	19°28′32.605″S	116°28′45.030″E	WA-16-L
Goodwyn-6[1]	126	19°43′19.078″S	115°51′16.964″E	WA-5-L
Angel-1[1]	91	19°30′14.901″S	116°35′52.544″E	WA-3-L

[1] Temporarily abandoned exploration wells

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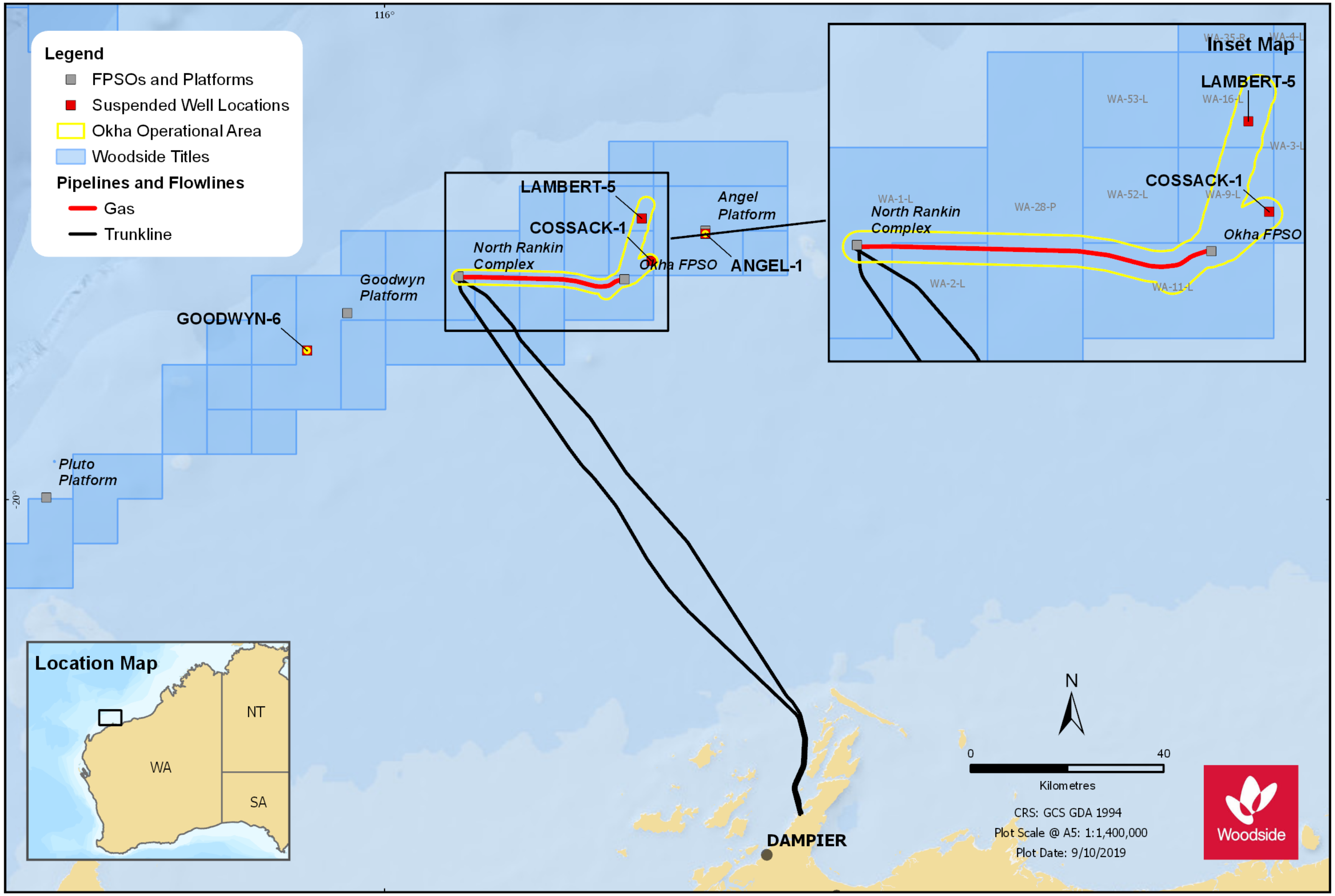

Figure 3-1: Okha FPSO and Operational Area

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3.3 Operational Area

The Operational Area applicable to the scope of this EP is shown in Figure 3-1 and includes:

- the Okha FPSO and the area around the facility extending out to 1500 m to allow for offtake activities (including the 500 m PSZ)
- the Okha FPSO subsea infrastructure, including wells and flowlines, and an area 1500 m from the infrastructure
- the temporarily abandoned exploration wells (Lambert 5ST1, Cossack-1, Goodwyn-6 and Angel-1) and an area of 500 m around each well
- the WC GEL ending at the outboard flange of NRA pipeline end module, and an area within 1500 m of the infrastructure.

Vessel-related activities within the Operational Area will comply with this EP. Vessels supporting the Petroleum Activities Program when outside the Operational Area must adhere to applicable maritime regulations and other requirements. This EP applies to activities undertaken within the Operational Area, as described in this section.

3.4 Timing

The Okha FPSO commenced production in September 2011. From 1995 to September 2011, the CWLH oil fields were produced through the Cossack Pioneer FPSO. The Okha FPSO operates 24 hours a day, 365 days a year. Supporting operations, such as maintenance activities, take place as required.

The CWLH fields are predicted to remain active during the life of this EP. Tie-back opportunities, which have the potential to extend the life of the field, are continuously being reviewed for Woodside's offshore facilities.

3.5 Facility Layout and Description

This section summarises the Okha FPSO and associated infrastructure, as relevant to consideration of the environmental risks and impacts of the Petroleum Activities Program.

3.5.1 Topsides

The Okha FPSO is a converted double-hull tanker, 318 m long and 48 m wide. The topsides processing facilities comprise oil, water, and gas separation systems, well service pumping, gas compression equipment, gas dehydration, fuel gas, flare, and other utility systems (Section 3.6.8).

The process and utility equipment on the topsides comprises 11 pre-assembled units (PAUs), which are elevated above the FPSO deck and have a plated lower deck and grated upper decks. Each PAU has its own primary structure, equipment, and associated piping, valves, and instrumentation. Process equipment is located as far as possible from the accommodation facilities, the primary Temporary Refuge, and the Central Control Room (CCR), all of which are at the stern of the vessel. A number of laydown and supplies handling and storage areas are also provided.

The PAUs (see Figure 3-2 for locations) are:

- M01: Separation
- M03: Export Gas and Compression
- M05: Gas Lift Compression
- M06: Flare Knock Out (KO) Drum
- M07: Gas Processing

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- M08: Portside Laydown / Chemicals
- M11: Power Generation and Utilities
- M12: Power Generation
- M13: Local Equipment
- M20: Pipe Rack
- M25: Flare Stack.

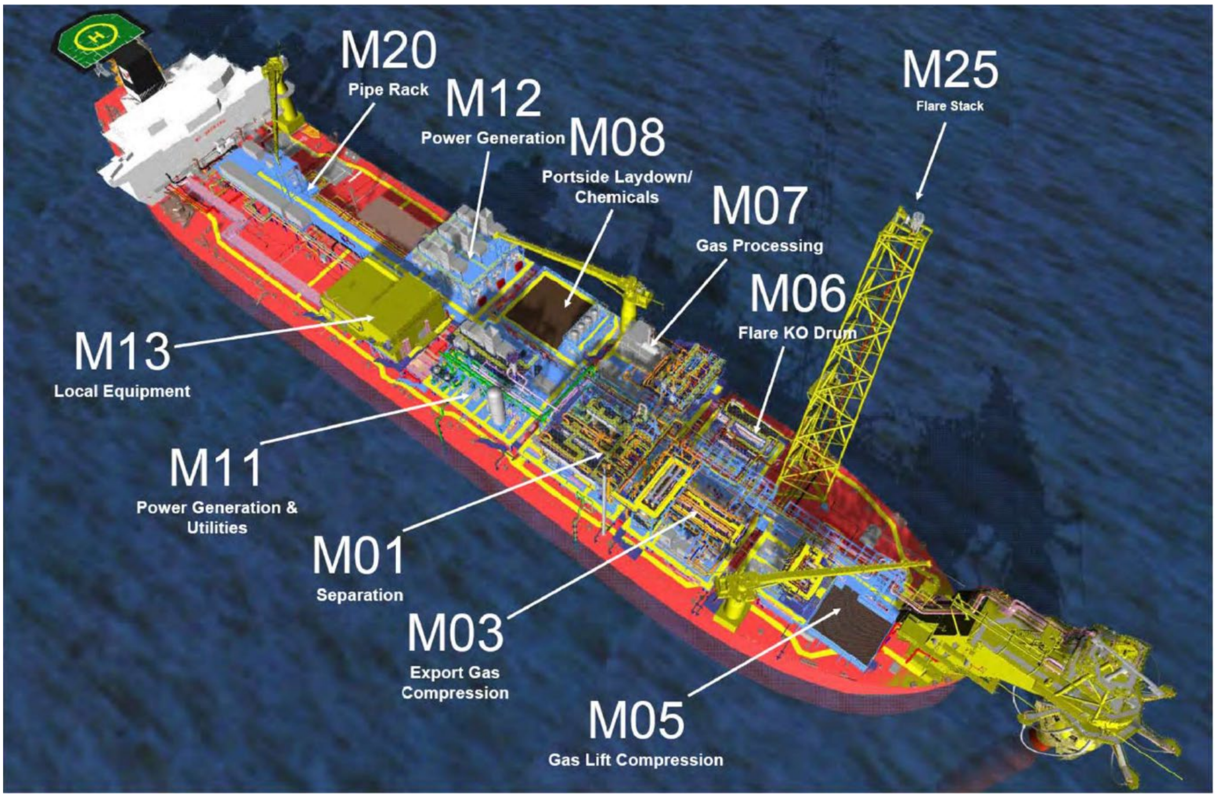

Figure 3-2: Okha FPSO topsides layout

3.5.2 Wells and Reservoirs

Thirteen subsea production wells are tied back to the Okha FPSO via five production manifolds. Table 3-2 lists the wells for the CWLH reservoir fields.

Table 3-2: Reservoir fields and their wells

Reservoir Field	# of Wells	Well Names
Cossack	1	CK4
Lambert	2	LA4, LA7
Hermes	2	LH3, LH6
Wanaea	8	WA1, WA2, WA3, WA11, WA6, WA7, WA8, WA9

The CWLH fields contain light crude oil with varying gas-to-oil ratios. The oil from the Wanaea reservoir has a relatively high gas-to-oil ratio, while the Cossack, Lambert, and Hermes reservoirs do not contain as many light components.

All producing wells use gas lift to optimise production. Gas lift is supplied from the Okha FPSO and is distributed to individual wells via flowlines interconnecting the gas lift integrated manifold, the gas lift inline skid, and the gas lift end skid.

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The Okha FPSO facility's Integrated Control and Safety System (ICSS) monitors all subsea Xmas tree instrumentation and operates subsea tree valves via the subsea control system. A surface controlled subsurface safety valve (SCSSV) is installed ~150 m below the seabed on each well as the downhole well barrier. These valves are designed fail safe to automatically close upon a loss of hydraulic pressure.

3.5.2.1 Temporarily Abandoned Exploration Wells

There are four temporarily abandoned exploration wells that fall within the scope of this EP. These wells are not tied back to the Okha FPSO and will be monitored and inspected based on a risk assessment. The wells are maintained in accordance with the subsea IMMR activities until they are permanently plugged for abandonment (subject to a separate EP). Temporarily abandoned exploration wells are not subject to the requirements of Performance Standard P10 – Wells, but are part of an accepted Well Operations Management Plan (WOMP).

3.5.3 Subsea Infrastructure

The main components of subsea infrastructure include wells, wellheads, Xmas trees, manifolds, spools, flowlines, jumpers, umbilicals, risers and the gas export riser, flowline and WC GEL. The layout of the Okha FPSO subsea infrastructure is shown in Figure 3-3.

The subsea system is typically controlled from the Okha FPSO via ICSS through these components:

- umbilicals, which provide hydraulic control, electric power and chemical injection from the FPSO and subsea components. Umbilicals run between the FPSO and manifolds and electrohydraulic jumpers run from manifolds to Xmas trees
- valves and chokes to control subsea operations and processes
- subsea control modules (SCMs), which are sealed and pressure-compensated electrohydraulic units (typically found on the manifolds and/or Xmas trees) and link the surface and subsea systems.

A number of subsea valves may be overridden manually by divers, or from a remotely operated vehicle (ROV).

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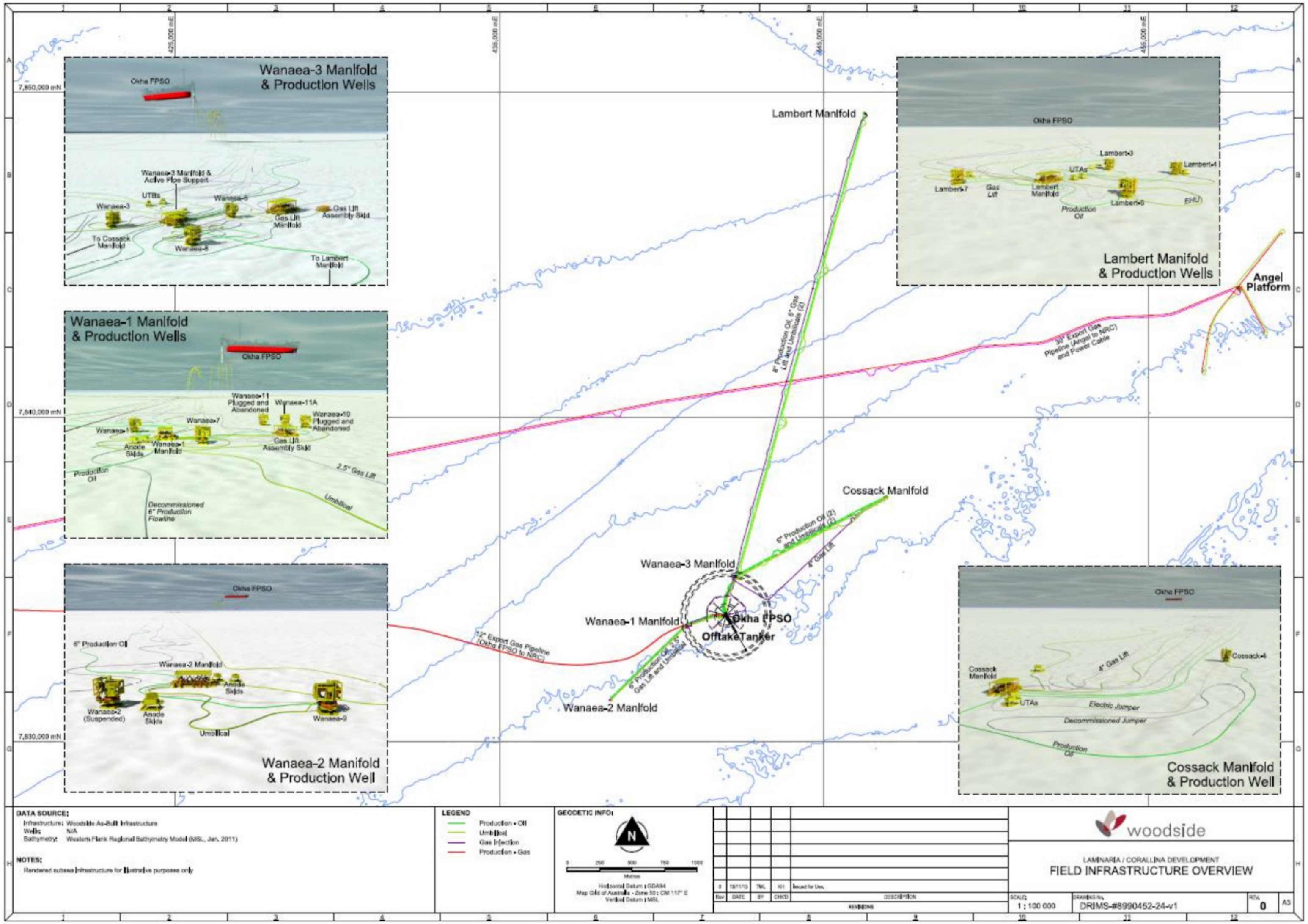

Figure 3-3: Okha FPSO subsea infrastructure

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3.5.4 Gas Export Line System

Gas is exported from Okha FPSO via a 197 m riser and a 420 m flexible flowline that transports gas to the WC GEL pipeline. WC GEL is 12 inches in diameter and transports gas from the Okha FPSO to either trunklines and onshore to the KGP. The WC GEL route begins downstream of the Okha gas export riser emergency shutdown valve (RESDV) and runs 32 km westwards to the outboard flange of the NRA pipeline end module adjacent to the NRC.

The topsides design allows for export gas to be back-flowed from the WC GEL to the high-pressure (HP) separator for supplying initial fuel and lift gas via the export gas compressors for well kick-off.

3.5.5 Riser Turret Mooring System

The Okha FPSO is moored over the central area of the Wanaea field, via a rigid arm to a riser turret that is anchored to the seabed with eight anchor chains and associated gravity-based anchors. The mooring configuration is shown in Figure 3-4.

The primary functions of the RTM are to:

- moor the Okha FPSO on station and allow the vessel to freely weathervane
- allow connection to / disconnection from the riser column if weather conditions exceed the design limits of the connected system, or planned remedial or modification works are undertaken
- support the flexible risers and the mooring chains in both connected and disconnected modes
- provide fluid transfer and control system communication between the Okha FPSO and subsea infrastructure.

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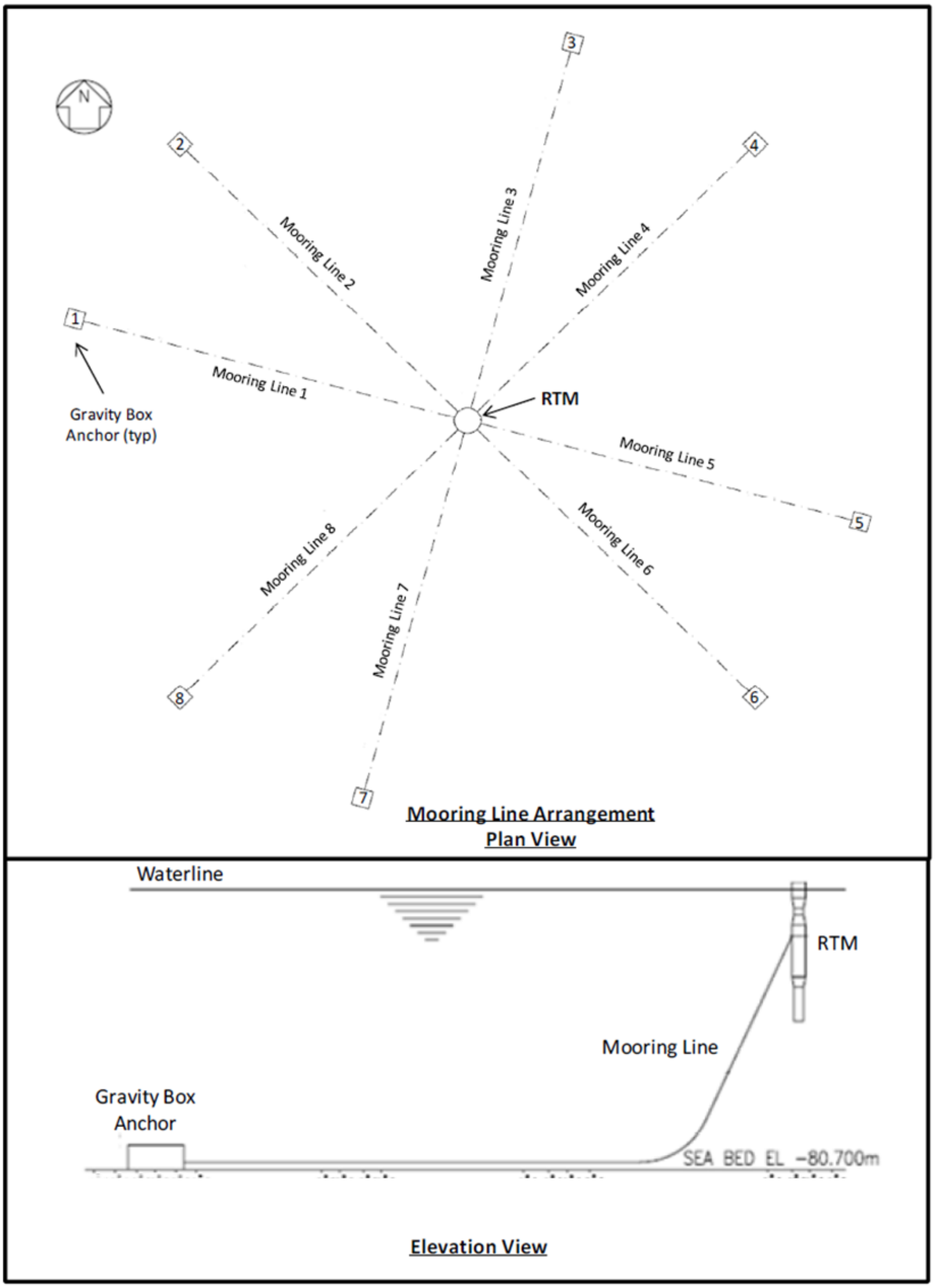

Figure 3-4: Okha FPSO mooring configuration

3.5.6 Disconnection and Reconnection of FPSO from the Mooring and Riser Column

Disconnecting and reconnecting the Okha FPSO from the riser column buoy is conducted in accordance with specific procedures. In preparation for disconnection, production is shut down, and the topsides, risers, and flowlines are depressurised via the flare system. The risers are depressurised to a nominated safe pressure before closing the RESDVs and isolation valves. Before being disconnected, the piping within the column and swivel are drained, flushed, and purged.

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Disconnection is achieved by disengaging the structural connector that links the universal joint to the top of the riser column. Upon disconnection, the riser column drops down from the rigid arm on the Okha FPSO and remains afloat. Once disconnected, the Okha FPSO operates as a seagoing vessel and complies with regulatory maritime requirements.

Reconnecting the two hubs of the structural connector is done by lifting the riser column with a heavy steel wire rope, which passes through the centre of a hollow steel guide piece incorporated in the structural connector body. This piece provides a centring function when it engages; in the final lifting phase, the two connector hubs are guided into contact.

3.6 Operational Details

This section describes the main operations associated with the Okha FPSO. It includes key elements relating to interactions between the activity and the environment, as described further in these sections:

- Manning and Modes of Operation (Section 3.6.1)
- Process Description (Section 3.6.2)
- Facility Utility Systems (Section 3.6.8)
- Facility Operations (Section 3.6.9)
- Hydrocarbon and Chemical Inventories and Selection (Section 3.9)
- Subsea Inspection, Monitoring, Maintenance, and Repair (IMMR) Activities (Section 3.10)

3.6.1 Modes of Operation

Normal operations at the Okha FPSO fall under any one of these main modes of operation, some of which may occur concurrently:

- production and maintenance, including subsea IMMR activities (Section 3.6.1.1)
- major projects involving refurbishment, modification, or major maintenance on the facility (Section 3.6.1.2)
- FPSO marine (disconnected) mode (Section 3.6.1.3).

The CCR is staffed 24/7 for all modes of operation.

3.6.1.1 Production and Maintenance

Production and maintenance covers hydrocarbon receipt, processing, storage for offtake, offtake to export tankers and supporting operations. IMMR activities are undertaken concurrently to maintain production within the Okha FPSO design constraints.

3.6.1.2 Major Projects

Major projects involve refurbishing, modifying, or undertaking major maintenance on the facility. Major maintenance or project work is normally completed outside the operational area.

3.6.1.3 FPSO Marine (Disconnected) Mode

The Okha FPSO can operate as a self-propelled vessel to avoid adverse weather conditions or for remedial maintenance or modifications at a shipyard. Once disconnected from the RTM, the Okha FPSO complies with all applicable maritime regulations. The Okha FPSO is not covered by this EP when it is operating in marine mode (i.e. disconnected) outside the Operational Area.

The Okha FPSO is maintained with sufficient personnel and in a condition such that it is prepared to disconnect at all times. Criteria for disconnecting from the mooring resulting from adverse weather

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include considering the predicted wind speed, currents, and wave heights, and comparing these to the vessel's operational limits and its anticipated pitch, roll, heave, and draft.

3.6.2 Process Description

The Okha FPSO receives well fluids (crude oil, gas, and associated produced water [PW]) from the production wells for topside processing, which includes:

- separating gas, crude oil, and water
- compressing and exporting gas
- treating and disposing of PW.

The Okha FPSO directly exports processed crude oil by offtake to offtake tankers. The facility is designed to process 60,000 bbl/d of oil and 100,000 bbl/d of water, and the gas compression trains can produce up to 82 MMscfd of export gas and up to 60 MMscfd of lift gas. The first processing stage is separating the well fluids in the HP and test separators. Fluids are then further separated in the low-pressure (LP) separator, and the crude is subsequently cooled and discharged into the FPSO oil storage tanks. Gas evolved from the LP separator is fed to the cargo tanks to provide gas blanketing, and to the flash gas compression system.

Figure 3-5 is a schematic diagram of the Okha FPSO process, which is described in more detail in the subsections below.

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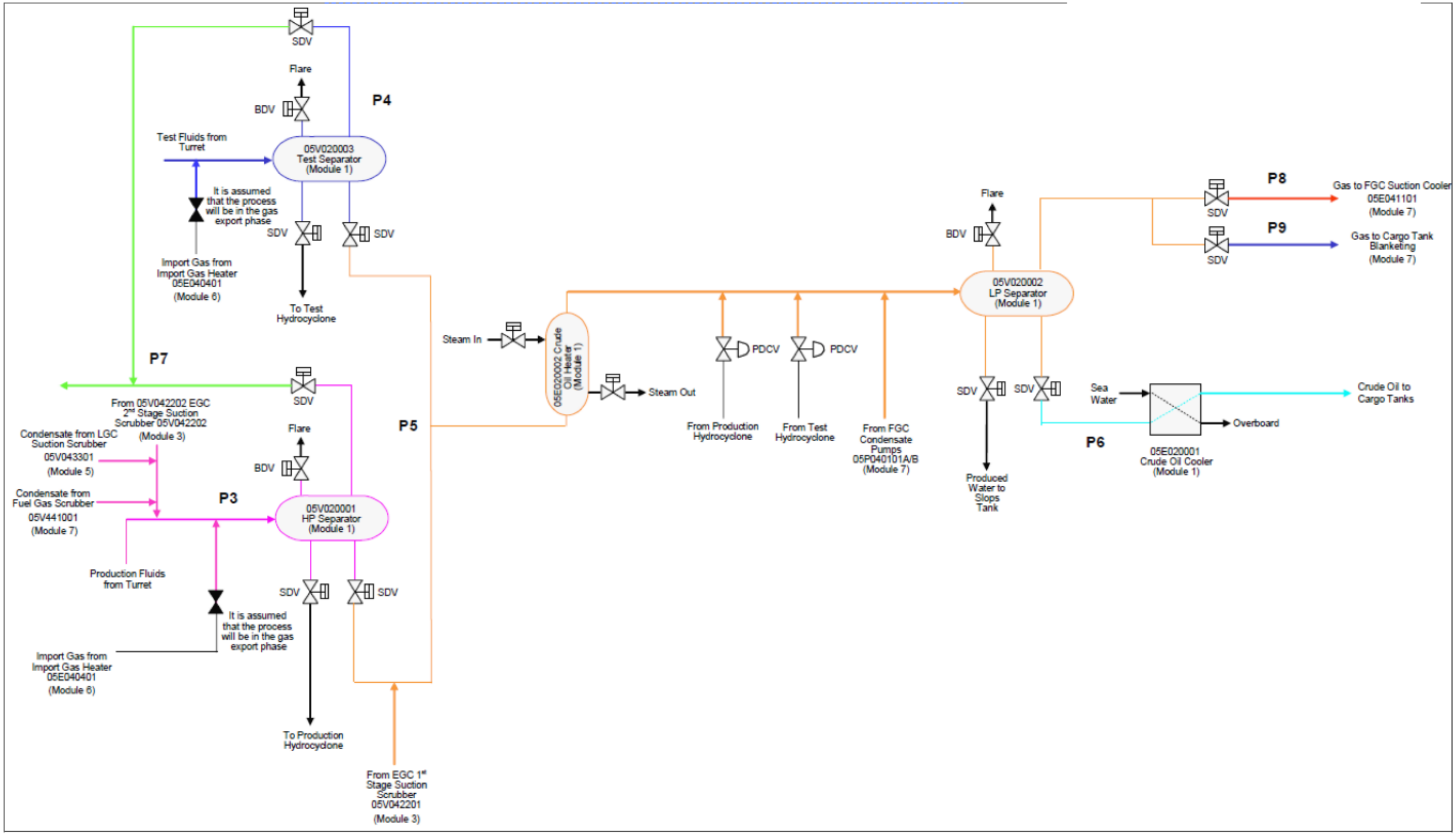

Figure 3-5: Okha FPSO process flow diagram

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3.6.2.1 Flare Systems

The Okha FPSO is equipped with a normally closed flare system, comprising HP and LP headers. Flare headers safely collect and remove vapours and liquids venting from the topside module pressure safety valves, blowdown valves, flare relief pressure control valves, and manual vents.

Flare scrubbers collect liquid that may be vented to the flare headers (or have condensed in the flare headers) to prevent burning liquids exiting the flare tips. Flare stacks exit the flare scrubbers and terminate at separate flare tips. The flare tips are closely aligned and are ignited by a flare ignition package. The HP and LP flare towers are at the bow of the Okha FPSO and are ~82 m high above deck and ~98 m above sea level.

Normal Operations

During normal operations, no continuous flaring (including flare purge/pilot) will occur due to the closed-loop design flare system. HP flare purge gas is recovered via the flash gas compressor and LP flare header purge gas / cargo tank flash gas is recovered via the vapour recovery unit (VRU). There are no pilot gas supplies to the flare tips as flare ignition is achieved by an ignition pellet launch system. Purging of the flare stack (the piping from the flare drum outlet isolation valves) to the flare tips is achieved via a nitrogen gas supply. Woodside anticipates that no gas will be continuously flared during normal operations, based on system design and operational experience. If there is a gas release to flare that cannot be accommodated by the recovery system, flow to that recovery system will stop and will be redirected to the respective flare. The flow of gas through each of the HP and LP flare systems is measured using separate flow meters.

Intermittent Process Upsets and Activities

During process upsets, the process control valves on the main process equipment will open to relieve excess pressure to the HP flare. The HP flare tip allows continuous flaring at the full gas production of 90 MMscfd (125,000 kg/hour) and an emergency rate of 133 MMscfd (185,000 kg/hour). The LP flare tip allows continuous flaring at the full gas production rate of 16 MMscfd (38,000 kg/hour) and an emergency rate of 23.5 MMscfd (49,0000 kg/hour).

Emergency Flaring

After an emergency trip of the topsides, the HP inventory in the topsides piping, trains and equipment will be sent to flare to safely remove all HP gas sources and depressurise topsides equipment. The topsides equipment and piping is divided into isolatable sections, each with a dedicated blowdown valve (BDV). During an emergency shutdown, each section is separately depressurised to the HP or LP flare. Each section contains a fail open actuated BDV, which allows blowdown of the entire facility inventory.

Manual Depressurisation

Manual depressurisations will result in intermittent flaring of hydrocarbons, triggered by routine equipment maintenance, planned emergency shutdown testing and/or depressurising equipment and piping to remove the equipment from service. Equipment must be depressurised before draining because the drains system is not intended for HP service.

Subsea Flowline Depressurisation

On rare occasions, the fluid in the subsea flowlines/pipelines (which carry hydrocarbons from the subsea wells to the Okha FPSO) may need to be routed to the flare system to reduce pressure in the flowlines. The flowlines may need to be depressurised for these reasons:

- production flowline maintenance and critical leak-off testing
- to facilitate remediation if an unplanned hydrate blockage occurs in the subsea flowlines

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- manage flowline integrity limit
- suspend redundant pipelines/flowlines.

3.6.3 Produced Water System

Produced water (PW) can comprise produced formation water (a water reservoir below the hydrocarbon formation), condensed water (water vapour present within gas/condensate that condenses when brought to the surface), or both. PW is separated out from the hydrocarbon components during the production process and discharged to the marine environment. PW is discharged via a caisson from the side of the ship between 4 m and 12 m below lowest astronomical tide (LAT) (the exact depth varies with ballast/loading) or via the slops tank at surface.

The Okha FPSO has been designed to process 18,000 m^3 of PW per day; however, discharge rates are typically much lower—in 2018, the Okha FPSO discharged 6,350 m^3 per day. Overall, Woodside expects that PW rates will increase as the CWLH fields age.

3.6.3.1 PW System Description

The PW system on the Okha FPSO comprises lines that connect the process to the HP separators, the PW hydrocyclones, and the LP separator (Figure 3-6).

The PW stream primarily comprises:

- water recovered from the well fluid stream by the HP separators or test separators that has been treated by the PW hydrocyclones
- PW diverted from the LP separator to the slops tank for first-stage gravity settling.

The Okha FPSO PW system:

- cleans the separated PW of oil and particulate contaminants
- cools and de-gasses the PW.

PW that is separated out in the HP and test separators is routed under level control to three hydrocyclones to remove any residual oil droplets and particulates.

De-oiled water from these hydrocyclones is sent to the PW flash drum. Reject oily water is fed to the LP separator. The flash drum has a hydrocarbon skimming facility to remove any residual oil that collects in the vessel. Skimmed oil is routed to the slops tanks. Separated gas from the flash drum is sent to the vapour recovery unit (VRU) via the LP flare.

An online analyser monitors the oil-in-water (OIW) content:

- if the OIW content is within specification, the PW is discharged directly overboard
- if the OIW content is off specification, the PW is automatically diverted to the slops tank for further treatment (separation) before being discharged in accordance with the EP requirements.

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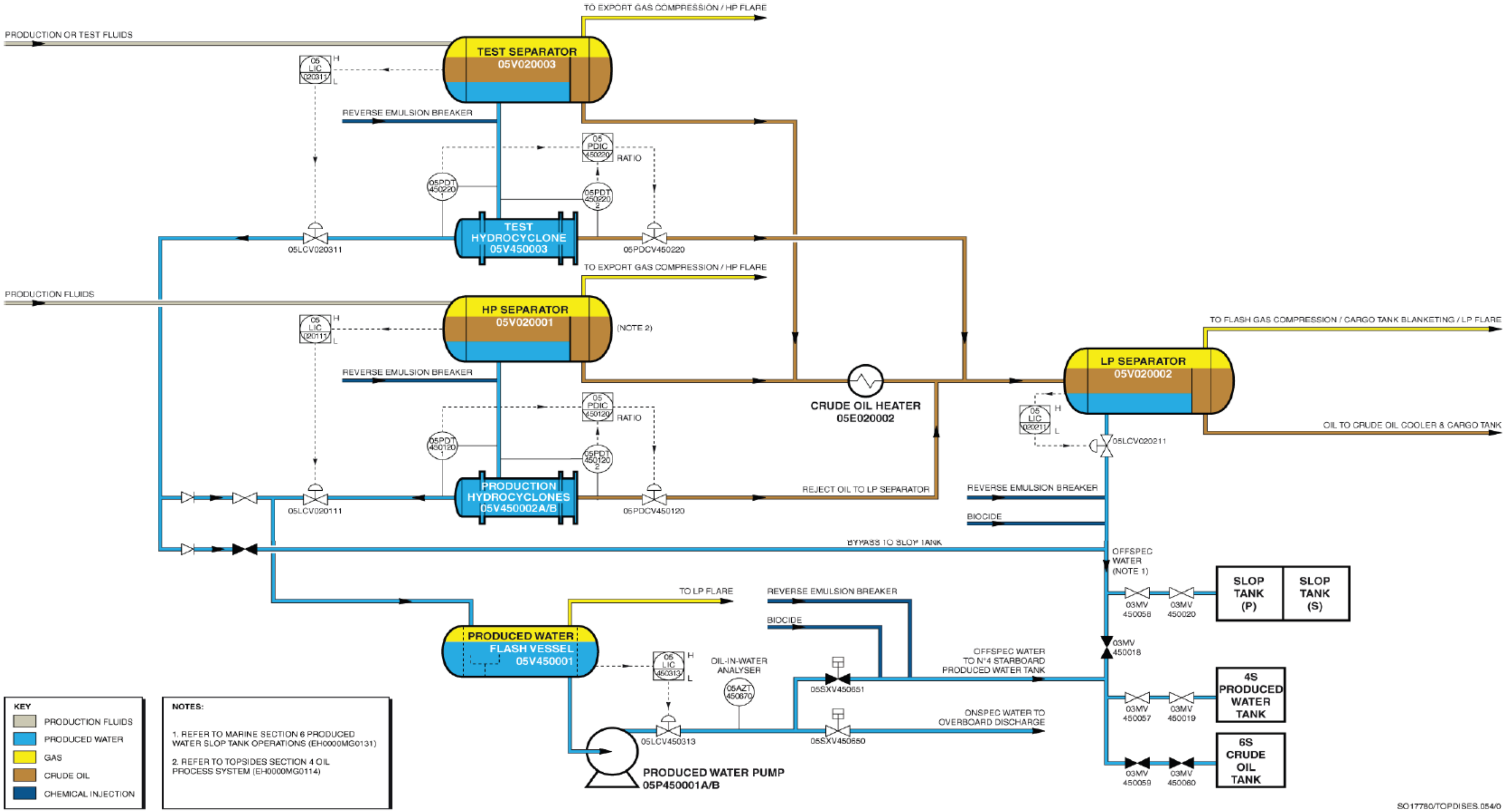

Figure 3-6: Okha produced water system overview

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3.6.4 Drainage Systems

The Okha FPSO topsides / RTM has three drainage systems (see Figure 3-7):

- Non-hazardous open drain: Collects drain fluids (e.g. rain water) from non-hazardous areas and disposes of them to the slops tanks, or overboard in case of a major deluge of fire water or rain water.
- Hazardous open drain: Collects drain fluids (e.g. oil-contaminated water) from hazardous areas and routes them to the slop tanks; includes the drain lines from the different levels of the RTM. The oily water in the slops tanks is separated by gravity and after settling is discharged in accordance with legislative requirements. There is provision to chemically treat slops water and/or transfer to different tanks if required. Oil recovered in the slops tank is routed to the cargo storage tank.
- Maintenance drain: Four drains help remove large volumes of hydrocarbon vapour and liquids (used for maintenance purposes), from the compressor scrubbers and separators. These drains directly tie into the cargo tank header, and from there—depending on operational requirements—hydrocarbons are directed to the applicable cargo tank.

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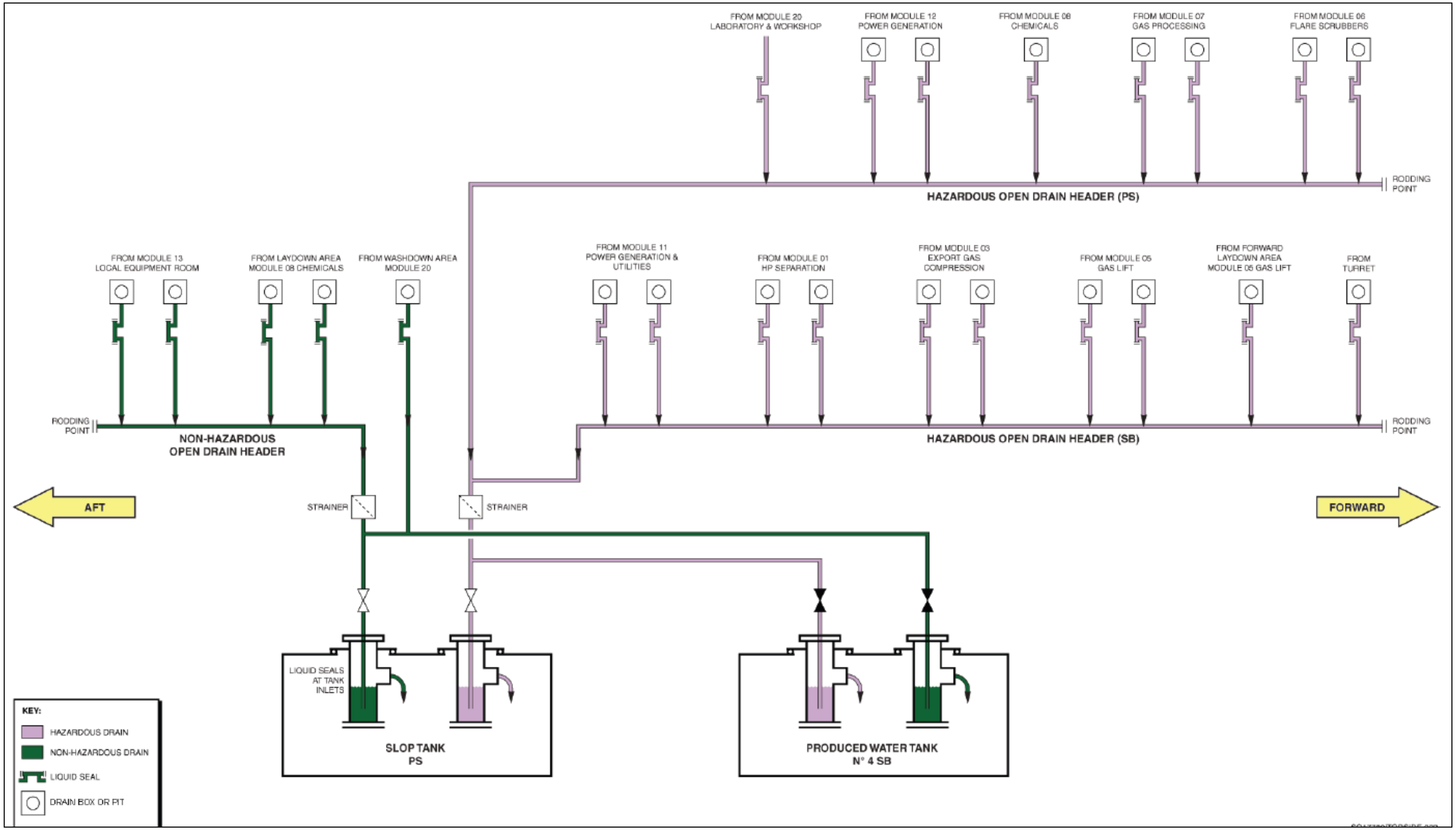

Figure 3-7: Okha FPSO hazardous and non-hazardous drains system

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3.6.5 Cargo Tanks

The Okha FPSO has 11 dedicated cargo tanks that are designed to receive and store crude oil directly from the topside process plant. The crude oil is fed from the topsides directly to the cargo tank by dedicated drop lines into the top of each cargo tank. The individual storage tanks vary in capacity, with a total operational storage capacity of 934,000 bbl of oil.

Three cargo pumps in the cargo pump room are used to transfer the crude oil to offtake tankers and redistribute crude oil around the cargo tanks. The pump valves are hydraulically operated from the CCR. During cargo export, two cargo pumps are available to achieve the required maximum offtake rate of 4000 m^3/hour.

The Okha FPSO is designed to load and discharge concurrently while maintaining double-valve segregation between incoming and exported crude oil and between crude and PW systems. Cargo loading and discharge is controlled from the CCR.

3.6.6 Offtake System and Offtake Tanker Mooring

Offtake operations from the Okha FPSO happen about every three weeks. The Okha FPSO has a tandem offtake system, which provides handling facilities to non-dedicated tankers up to 150,000 T. Steam-driven pumps are used to pump offtake crude oil to the offtake tanker via cargo piping that leads to a 20-inch diameter floating hose. This hose is stored on a reel at the stern of the Okha FPSO when not in use to reduce the likelihood of hose damage during handling or impact by vessel. The hose is made of heavily reinforced material in sections ~10 m long and has flanged and bolted connections between sections; this allows each section to be independently tested and replaced if necessary. A double dry break coupling, which releases automatically at a pre-set tension, is fitted ~15 m from the offtake rail end of the hose.

3.6.7 Ballast System

The Okha FPSO seawater ballast system is used to counteract shear force and bending movement stresses on the FPSO's hull caused by loading and offtake crude oil in the vessel's storage tanks. Ballasting also controls the trim and heel of the vessel to ensure stability remains within the design limits.

Segregated ballast is carried in the fore and aft peak tanks of the FPSO, and in six pairs of wing tanks arranged the entire length of the cargo tank area. The total capacity of the segregated ballast tanks is ~51,600 m^3. All ballast pumps are interconnected to allow flexible operation.

Ballast tanks are filled and discharged by ballast water pumps or gravity until the water level in the tank equalises with the draft level of the Okha FPSO.

The volumes of the main ballast tanks are controlled by two centrifugal pumps, which are located in the pump room and have their own sea chest. The pumps are connected to an overboard discharge line that ends ~0.5 m above the deepest water ballast line on the port side.

3.6.8 Facility Utility Systems

3.6.8.1 Facility FPSO Lighting

Okha FPSO lighting is split between emergency and normal lighting. Battery-backed emergency light fittings illuminate designated escape routes.

Navigational lights are on the Okha FPSO flare tower and on the crane booms and tower. Helideck lighting assists helicopter landing. Unless required to support over-the-side activities (such as refuelling and lifting operations), lighting on the Okha FPSO is directed to the work area, which helps limit light to sea.

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3.6.8.2 Heating Ventilation and Air Conditioning

The heating, ventilation, and air conditioning (HVAC) system comprises HVAC equipment, ductwork, and associated pipework. It provides independent and inter-dependent subsystems with pressurised, conditioned, purged, and exhaust air services to various areas, including accommodation and various modules. Various parts of the HVAC system can be operated on an 'as required' or continuous basis.

Mechanical exhaust systems supplement ventilation and HVAC systems, fume extraction systems, and are used in any negatively pressurised areas. Ozone-depleting substances are no longer used on the Okha FPSO and refrigerants associated with the HVAC system are managed by a licensed refrigerant authority.

3.6.8.3 Steam System

Two auxiliary boilers provide steam to the Okha FPSO steam distribution system. They are configured for dual-fuel operation using gas and diesel or steam for atomising diesel. One boiler is sufficient to meet the steam requirements during normal production and utilities operating mode. However, during cargo offtake when two cargo pumps are in operation, both boilers operate in parallel to meet the increased steam demand.

3.6.8.4 Cooling and Freshwater Treatment Systems

Seawater System

The topsides seawater system provides seawater cooling to the central coolers (heat exchangers) where the cooling medium system transfers the waste heat from the machinery and utilities to the sea water. Sea water dosed with biocide may be injected into the subsea production system for periods of extended flow line shut-in to prevent sulfur-generating bacteria and thus the build-up of hydrogen sulfide in the subsea system. The sea water will be sent via the well services pump and production and test headers to the subsea flowline. Oxygen scavenger can also be injected into this flow stream. Two lift pumps discharge sea water via coarse filter screens overboard at a disposal temperature of ~20 °C above ambient sea water temperature, with the third pump on standby. Maximum discharge rate of the system is 2670 m^3/hour. Each pump is submerged in a dedicated suction caisson. Hypochlorite from the hypochlorite generator package is injected into the seawater suction systems to prevent marine growth.

Other continuous sea water systems (both part of the hull seawater system) that continuously discharge sea water include:

- two air conditioning cooling water pumps are used to supply cooling sea water to the air conditioning condenser before discharging overboard at a maximum flow rate of 390 m^3/hour. Either pump can be selected as duty or standby.
- three seawater cooling pumps that are configured as required to supply cooling water to the low temperature freshwater coolers in the engine room of the FPSO. Maximum discharge rate of each pump is 400 m^3/hour.

Based on the continuously discharging cooling water systems described above and other intermittent cooling systems, the typical volume of cooling water discharged is 57,000 m^3/day. The maximum potentially discharged volume is 102,240 m^3/day based on the integrity limit of the equipment.

Topsides Cooling Medium System

The topsides cooling medium water system on the Okha FPSO provides indirect cooling by recirculating chemically treated distilled water through a closed-loop system to remove heat from process and utility coolers. Cooling medium is circulated around the system by the cooling medium circulation pumps. The cooling medium pumps take suction from the cooling medium expansion

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vessel, which is located at the system high point. From the pumps, cooling medium is fed to the plate heat exchangers where it is cooled by the seawater system. From these exchangers the cooling medium is distributed to all users.

To prevent general corrosion, fouling, and blocking small passages in the heat exchangers, the cooling medium system is dosed as required with oxygen scavenger, pH buffer, and biocide. Periodic system maintenance may require the sections in the cooling medium system to be drained, resulting in the discharge of water and residual treatment chemicals to the marine environment.

Marine Freshwater System (Hull System)

The freshwater cooling system (closed-loop) comprises two separate systems: a high temperature (HT) and a low temperature (LT) cooling freshwater system. Cooling medium used in both the LT and HT cooling systems is a solution of fresh water and chemical corrosion inhibitor. The HT cooling water system provides cooling water to the main engine water jacket and heating water for the No. 1 and 2 freshwater generators. The LT cooling water system provides cooling to the bulk of the FPSO's engine room machinery, including the cold water side of the main engine jacket freshwater cooler and the auxiliary engines' cooling water jackets.

Potable Water

The three freshwater generators provide water to the potable water tank and the distilled water tank. The system is designed to provide an adequate supply of boiler water plus a daily fresh water supply rated at 20 m^3/day. Approximately 60 m^3/day of brine is discharged (20 m^3 per generator) as a result of this process.

A hydrophore system with pressurised tanks, pumps, filters, sterilisers, and a calorifier provide the potable water distribution system for the accommodation facilities with a pressurised hot and cold water supply. Fresh water can also be bunkered into the storage tanks using the freshwater bunker filling hose located at the upper deck supply boat landing area.

3.6.8.5 Hydrocarbon Blanketing and Inert Gas System

The Okha FPSO uses hydrocarbon gas as the primary medium for topping up and inerting the cargo tanks during loading, storage, production, and offtake operations. The system is designed to eliminate the emission of cargo tank vapours, which would conventionally be cold vented through the cargo tank vents. The system prevents an explosive atmosphere in the cargo tanks by excluding air (oxygen) from the tanks and maintaining a 100% hydrocarbon blanket in the vapour space of the tanks.

Hydrocarbon gas is produced by the LP separator on topsides and distributed to the cargo tanks via a dedicated header and associated tank branches. Hydrocarbon gas is also produced by the crude oil boiling off inside the cargo tanks. This gas is recovered by the VRU, which manages the tank pressures during normal operations.

Inert gas is produced on the Okha FPSO by the auxiliary gas-/diesel-fired boilers. If the hydrocarbon gas blanketing supply is unavailable for any reason (e.g. an oil process system trip, tank entry activity, purging of cargo tanks of air prior to loading with oil, sailing mode or riser disconnection), the inert gas system is brought on line to preserve the inert gas blanket in the cargo tanks until the hydrocarbon gas blanketing system can be reinstated.

3.6.8.6 Power Generation

The main power generation for the Okha FPSO is supplied by four 12.5 MVA gas turbine driven generators. The entire Okha FPSO can consume 21 MW of power for normal operating conditions, which includes offtake operations. This power is normally supplied by two online gas turbines, with the remaining two as spare or out of service for maintenance.

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The turbines operate on fuel gas during normal operations, but can run on diesel during process upsets, facility start-up, or when bringing a turbine back into service after maintenance. When the facility is off station in sailing mode, power generation is supplied by the three 900 kW diesel generators located in the engine room.

Emergency power is supplied by a single 880 kW emergency black-start diesel generator. This emergency generator supplies power to the Okha FPSO's emergency switchboard, which then provides power to auxiliary equipment such as pre-lube and starting air supply for the essential generators. The emergency generator starts automatically if mains power is lost. Two independent uninterrupted power supply (UPS) systems, which are physically separated from each other, provide redundant temporary power supplies for SCQ regardless of the state of emergency (essential or main generation).

3.6.8.7 Fuel Gas System

The fuel gas system supplies superheated fuel gas at two pressure levels. HP fuel gas is only required for the power generator gas turbines. The consumers of LP fuel gas are the marine boilers, HP and LP flare header purge, triethylene glycol (TEG) regeneration package, and PW flash vessel gas outlet purge.

Total fuel gas consumption on the Okha FPSO is metered by a fuel gas flow transmitter. The average power consumption from maximum topsides power demand and others is ~108,250 sm^3/day and is expected to be relatively constant throughout field life.

3.6.8.8 Safety Features and Emergency Systems

Various safety features and emergency systems have been integrated into the design and operation of the Okha FPSO to manage safety risk and associated major environment risk. The safety features and emergency measures in place are listed in the Okha FPSO Safety Case.

3.6.8.9 Sewage and Putrescible Wastes

Sewage from the ablution areas is macerated and disposed of to the ocean via the hull discharge line (below the water line).

Putrescible waste (principally food scraps) is either ground to <25 mm diameter and disposed to the ocean or bagged and transported to shore for disposal as domestic waste.

3.6.9 Facility Operations

3.6.9.1 Lifting Operations

The Okha FPSO has four rotating pedestal cranes and one overhead crane, as well as numerous local handling/lifting equipment. Dedicated laydown areas (Figure 3-8) for materials, chemicals, and provisions are located to optimise lifting/handling and reduce manual handling. The subsections below give further details on the types of lifting activities and cranes used.

Routine Lifting from Facility Support Vessels

Routine lifting operations primarily include transferring stores and equipment from a support vessel to the main or stores laydown areas. Support vessels are equipped with dynamic positioning system (DP) for holding station during lifting operations. The types of lifted equipment varies, but generally include containers or skips of various sizes. Supply of chemicals are also routinely lifted, with the largest volume of transfer via container ~3.8m^3.

After offloading from the supply vessel is complete, the FPSO backloads to the supply boat any items to be returned to shore (e.g. empty containers or skips containing waste for onshore disposal).

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Lifting around the Facility

Once lifted to the laydown areas, repositioning to other locations may be required for stores, equipment, ISO containers, or waste bins. Occasionally, a non-routine piece of equipment may need to be lifted, in which case it is packed into a container or an approved lifting frame.

Operational Lifting (non-crane based)

Operational lifting may also require rigging, chain blocks, or electric hoists to be used. This lifting is primarily undertaken for maintenance or repairs and involves lifting and removing equipment such as valves, spools, or motors.

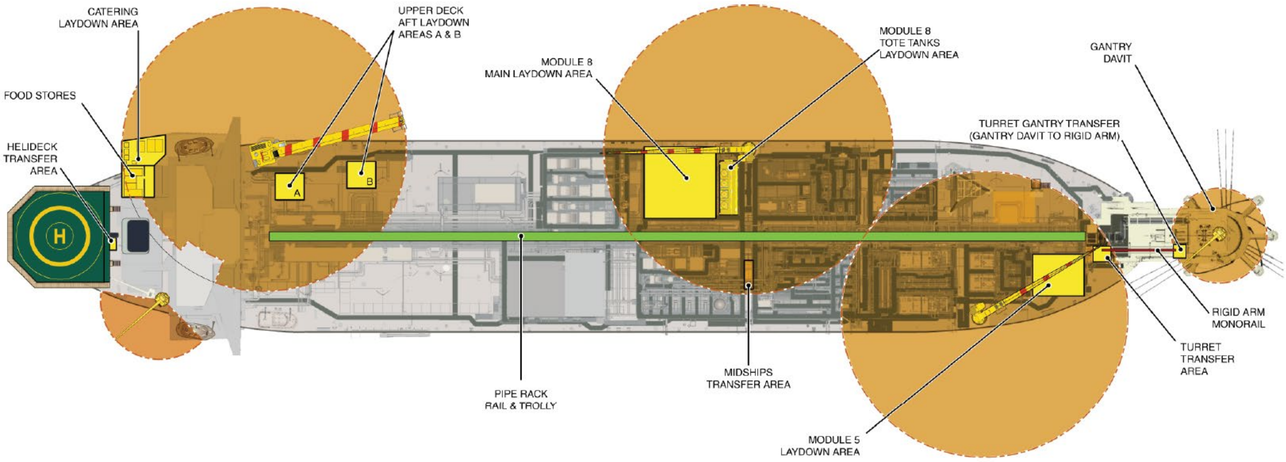

Figure 3-8: Okha FPSO main laydown areas

3.7 Vessels

3.7.1 Support Vessel Operations

Vessels, either LNG- or diesel-powered, are used in a support capacity for transferring materials, equipment, and personnel in emergency scenarios from the facility. Vessels are also used for project field work such as subsea intervention (e.g. IMMR of subsea infrastructure).

3.7.1.1 Facility Support Vessel

Various facility support vessels are used (depending on schedules and availability) to transfer material and equipment to and from the Okha FPSO. The specifications for the *Siem Thiima*—a typical support vessel—are listed in Table 3-3.

The *Siem Thiima* is the first LNG-powered vessel. Carbon emissions of LNG are up to 25% lower than diesel and 30% lower than heavy fuel, and this vessel emits almost no sulfur or particulates.

The current schedule is for a vessel to visit the facility fortnightly for supply activities, and as required for offtake support. While in the field, the vessel also backloads materials and segregated waste for transport to the King Bay Supply Facility in Karratha and carries out standby duties during activities such as helicopter operations and working over the side, when required.

Table 3-3: Indicative facility support vessel specifications (*Siem Thiima*)

Attribute	Details
Type	Facility support vessel
Length overall	89.2 m

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Attribute	Details
Breadth	19.0 m
Draft	7.6 m
Dead weight tonnage	5,500 T
Accommodation	Berthing for 25 personnel
Dynamic positioning system	DP2
Fuel capacity	964 m^3

3.7.1.2 Subsea Support Vessels

Subsea support vessels are used for subsea IMMR activities. Vessels vary depending on operational requirements, vessel schedules, capability, and availability.

Typical subsea support vessels use DP to manoeuvre and to avoid anchoring when undertaking works near subsea infrastructure. However, these vessels are also equipped with anchors, which may be deployed in an emergency.

3.8 Helicopter Operations

Helicopters are the primary means of transporting people and/or urgent freight to and from the Okha FPSO and are the preferred means of evacuating personnel in an emergency. No helicopter refuelling occurs on the Okha FPSO. Typically, six return trips per fortnight are undertaken; during campaign periods this frequency increases to approximately eight return trips per fortnight.

3.9 Hydrocarbon and Chemical Inventories and Selection

3.9.1 Hydrocarbons

The main bulk hydrocarbon inventories associated with major topsides process equipment are summarised in Table 3-4.

Table 3-4: Hydrocarbon bulk liquid inventories of major process equipment

Vessel	Liquid Volume (m^3)
HP separator	113.5
Test separator	26.3
LP separator	31.2
1st stage export gas compression	4.1
Export gas compressor 1st stage suction scrubber	4.1

3.9.1.1 Marine Diesel System and Bunkering

Diesel is transferred to the Okha FPSO from an supply vessel via a bunker hose reel that is transferred to the supply vessel with the use of the aft crane. The diesel is pumped from the supply vessel through the bunker station located on the port aft area of the main deck, to the bunker tanks located on the aft port and starboard sides of the FPSO.

Supply vessels transfer low-sulfur diesel to the Okha FPSO in bulk. The diesel is purified and held in settling and service tanks before being distributed for use to all on-board diesel-fuelled and -fired equipment. Diesel from the settling tank is transferred via the purifiers to the diesel service tanks, from where (if required) it can be used for the topsides gas turbines, generator engines, and the main engine. Outlet valves from the diesel tanks are fitted with quick-closing valves remotely operated from the FPSO's instant valve activation points.

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The turbine-driven generators and boilers have dual-fuel capabilities—fuel gas is their primary fuel, with diesel as a secondary fuel source. In addition, the system supplies diesel to the well service pump for valve equalisation, subsea dehydration, and well services. The system comprises three main interconnected systems—storage and transfer system; purification and service system; and equipment (consumer) supply systems. Diesel usage on the Okha FPSO is monitored and metered.

The storage and transfer system comprises the major components listed in Table 3-6.

Table 3-6: Storage and transfer system major components

Diesel Oil Tank Description	Volume
Bunker tank No. 3 (port)	1,230 m^3
Bunker tank No. 2 (starboard)	909 m^3
Bunker tank No. 1 (starboard)	527 m^3
Overflow tank	47.7 m^3
Settling tank No. 1	108 m^3
Service tank No. 2	93 m^3
2 × day tanks (for fire pumps)	2 × 6 m^3
1 × day tanks (for emergency generator)	1 × 6 m^3

3.9.2 Chemical Usage

Chemicals are used on the Okha FPSO for various purposes. and can be divided into two broad categories—operational and non-operational—as described below.

3.9.2.1 Operational Chemicals

Operational Process Chemicals

A process chemical is an active chemical added to a process or static system, which provides functionality when injected into produced fluid, utility system streams, or for pipeline treatment. Examples include corrosion inhibitors, biocides, scale inhibitors, demulsifiers, glycols, oxygen scavengers and hydrate inhibitors. These chemicals may be present in routine or non-routine discharge streams from the Okha FPSO.

Operational Non-Process Chemicals

Non-process chemicals are those that do not fall into the category described above. They may be required for operational reasons (e.g. maintenance or intervention activities) and once used, may be intermittently discharged or have the potential to be discharged. Examples include subsea control fluids, dyes, and well intervention/workover chemicals.

3.9.2.2 Non-Operational Chemicals

Non-operational chemicals include those required for general maintenance or housekeeping activities and are critical for overall maintenance of the Okha FPSO and its equipment. These may include paints, degreasers, greases, lubricants, and domestic cleaning products, as well as chemicals used for special tasks, such as laboratory testing and analysis. Maintenance chemicals generally present negligible risk to the environment because they are either not discharged when used (e.g. paint) or are used intermittently and discharged in low volumes (e.g. domestic cleaning products).

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3.9.2.3 Indicative Chemical Inventories

Table 3-5 lists the bulk chemicals commonly used on the Okha FPSO, and their estimated storage quantities. In addition to these, the Okha FPSO may also store small volumes of various operational chemicals and facility maintenance chemicals as described above.

Table 3-5: Indicative bulk inventories of chemicals

Material	Storage Method	Storage Capacity (m^3)
Biocide	Dedicated tank – chemical injection skid	~9
Scale inhibitor	Dedicated tank – chemical injection skid	~8
Emulsion breaker	Dedicated tank – chemical injection skid	~13
Reverse emulsion breaker	Dedicated tank – chemical injection skid	~11
TEG	Dedicated tank	~10
Subsea control fluid	Fluid stored in intermediate bulk containers	~4

3.9.2.4 Environmental Consideration during Chemical Selection, Assessment, and Approval

Operational chemicals required by the Petroleum Activities Program are selected and approved in accordance with Woodside's process for selecting and assessing chemicals. This process is used to demonstrate that the potential impacts of the chemicals selected are acceptable and ALARP, and that they meet Woodside's corporate requirements, which requires chemicals to be selected with the lowest practicable environmental impacts and risks, subject to technical constraints.

A summary of the environmental requirements of the Chemical Selection and Assessment Environment Guideline is outlined below.

Environmental Selection Criteria

Woodside's process for selecting and assessing chemicals follows the principles outlined in the Offshore Chemical Notification Scheme (OCNS), which manages chemical use and discharge in the United Kingdom (UK) and the Netherlands (background on the OCNS scheme is provided below).

Operational chemicals are selected/assessed in compliance with the Woodside's process for selecting and assessing chemicals, specifically:

- Where operational chemicals with an OCNS rating of Gold/Silver/E/D and no OCNS substitution or product warning are selected, or a substance is considered to pose little or no risk to the environment, no further control is required. Such chemicals do not represent a significant impact on the environment under standard use scenarios and therefore are considered ALARP and acceptable.
- If other OCNS-rated or non–OCNS-rated operational chemicals are selected, the chemical is assessed as follows:
  - If there is **no planned discharge** of the operational chemical to the marine environment, written technical verification of the 'no discharge' fate is provided and no further assessment is required.
  - If there is **planned discharge** of the operational chemical to the marine environment, a further assessment and ALARP justification is conducted.

The ALARP assessment considers chemical toxicity and biodegradation and bioaccumulation potential, using industry standard classification criteria (Centre for Environment, Fisheries and Aquaculture Science scheme criteria).

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If a product has no specific ecotoxicity, biodegradation, or bioaccumulation data available, these options are considered:

- environmental data for analogous products can be referred to where chemical ingredients and composition are largely identical; or
- environmental data may be referenced for each separate chemical ingredient (if known) within the product.

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

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

Once the further assessment/ALARP justification has been completed, confirmation that the environmental risk as a result of chemical use is ALARP and acceptable is obtained from the relevant manager.

Background Overview of OCNS

The OCNS applies the requirements of the Oslo–Paris Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention). The OSPAR Convention is widely accepted as best practice for chemical management.

All chemical substances listed on the OCNS list of registered products have an assigned ranking based on toxicity and other relevant parameters (e.g. biodegradation, bioaccumulation), in accordance one of two schemes (as shown in Figure 3-9):

- **Hazard Quotient (HQ) Colour Band:** Gold, Silver, White, Blue, Orange, and Purple (listed in order of increasing environmental hazard); or
- **OCNS Grouping:** E, D, C, B, or A (listed in order of increasing environmental hazard). Applied to inorganic substances, hydraulic fluids, and pipeline chemicals only.

Hazard Quotient Colour Band	Gold	Silver	White	Blue	Orange	Purple

OCNS Grouping	E	D	C	B	A

Lowest Hazard → Highest Hazard

Figure 3-9: OCNS ranking

3.10 Subsea Inspection, Monitoring, Maintenance, and Repair Activities

3.10.1 Overview

Subsea infrastructure is designed not to require any significant degree of intervention. However, inspection, monitoring and maintenance is undertaken to ensure the integrity of the infrastructure and identify any issues before they present a risk of loss of containment. Intervention may be required to repair identified issues. Subsea activities are typically undertaken from a relevant support vessel via an ROV and/or divers.

Interventions often require deployment frames/baskets, which are temporarily placed on the seabed. Typically, these have a perforated base with a seabed footprint of ~15 m^2. They are recovered to the

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vessel at the end of the activity. Subsea activities are broadly categorised into inspection, monitoring, maintenance, and repair activities, and typical IMMR activities are described below.

3.10.1.1 Inspection

Subsea infrastructure inspections physically verify and assess components to detect changes to the as-installed location and condition by comparing them to previous inspections. The scope and frequency of subsea and pipeline inspections are determined using risk-based inspection (RBI) methodology, resulting in detailed RBI plans. Table 3-6 lists typical subsea infrastructure inspections / surveys.

Table 3-6: Typical inspections / surveys

Type of Inspection / Survey	Purpose
General visual inspections	Check general infrastructure integrity
Close visual inspections	Investigate certain subsea infrastructure components
Cathodic protection	Check the system is protected against corrosion
Wall thickness surveys	Monitor the condition of subsea infrastructure. (i.e. ultrasonic testing)
Side scan sonar (SSS), multibeam echo sounder (MBES) and sub-bottom profiler (SBP) (Chirp)	Identify buckling, movement, scour, and seabed features. Low frequency/intensity signals
Non-destructive testing	Evaluate the properties of material/items using electromagnetic, radio graphic, acoustic resonance technology, ultrasonic, or magnetic equipment
Seabed sampling surveys including minor grabs/cores	Identify benthic fauna, sediment, etc. Grabs/cores are typically 0.1 m^2 per sample
Water sampling surveys	Determine water quality around pipelines
Anode sampling	Take samples of anode materials for testing
Marine growth sampling	Take samples of marine growth for testing
Laser surveys	Conduct dimensional checks on spools etc. and measure proximity

3.10.1.2 Monitoring

Subsea infrastructure monitoring surveys the physical and chemical environment that a subsea system or component is exposed to, to determine if and when damage may occur, and (where relevant) predict the rate or extent of that damage.

Monitoring activities may include process composition testing, corrosion probes, corrosion mitigation checks, metocean and seismic monitoring, and cathodic protection testing.

3.10.1.3 Maintenance

Maintenance activities on subsea infrastructure are required at regular or planned intervals to prevent deterioration or integrity failure. Maintenance activities may include cycling and actuating valves, flushing chemical/hydraulic fluid lines, and leak and pressure testing.

3.10.1.4 Repair

Repair activities are required when a subsea system or component is degraded, damaged, or has deteriorated to a level outside acceptance limits. Damage sustained may not necessarily pose an immediate threat to continued system integrity, but presents an elevated level of risk to safety, environment, or production. Typical subsea repair activities include, but are not limited to:

- SCM replacement
- hydraulic flying lead replacement

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- electrical flying lead replacement
- pipeline or spool support with grout bag or mattress
- spool disconnection and/or replacement
- umbilical jumper replacement
- riser or flowline replacement
- scour prevention installation
- corrosion protection.

3.10.1.5 Pipeline Pigging Operations

Pigging involves sending an internal pig through a pipeline using a process medium. During the pipeline lifecycle, pigging may need to be conducted for various reasons (e.g. IMMR or to facilitate modifications).

The WC GEL has been designed to operate in a non-corrosive condition, thus regular maintenance and cleaning pigging of the WC GEL is not required. Therefore, permanent pig launchers or receivers are not part of the subsea infrastructure. If any pigging activity was needed, a temporary subsea launcher and receiver would need to be installed. Flanged connections are provided in suitable locations to connect pig traps to allow pigging.

The risks and impacts of unscheduled pigging are included in Section 6.6.4.

3.10.1.6 Chemical Usage During IMMR Activities

Subsea Chemical Usage

Planned chemical discharges may occur during various subsea system operation and IMMR activities. However, these are either discharged in small volumes, or discharged intermittently. Operational chemicals used in the Okha FPSO subsea infrastructure are selected and assessed using Woodside's chemical selection and assessment procedures, as detailed in Section 3.9. Chemicals that may be released during IMMR activities; include, but are not limited to:

- subsea control fluid – a water-glycol based control fluid. The subsea control system is an open-loop system that releases hydraulic fluid during valve functioning and releases small quantities across control valves during steady-state operations
- hydrate control – monoethylene glycol (MEG) and triethylene glycol (TEG) are used for hydrate control
- scale inhibitor – scale inhibitor manages and prevents scale build-up within subsea equipment
- biocide – biocides prevent bacterial growth in pipelines that may cause corrosion
- dye – chemical dyes incorporated in the subsea control fluid identify the source of a leak
- acid – sulfamic (or equivalent) acid removes calcium deposits
- oxygen scavenger – oxygen scavenger de-oxygenates the pipeline to prevent corrosion and aerobic bacterial growth
- surfactant – surfactants remove water and organic deposits from pipelines
- grout – the material used in grout, mattresses, and rock is typically concrete-based.

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Typical Discharges During IMMR Activities

Minor environmental discharges are expected during subsea IMMR activities (e.g. during pressure / leak testing or flushing). Where possible, flushing is performed before a subsea component is disconnected to reduce residual hydrocarbon or chemical releases to the environment upon disconnection. The flushing chemicals used for this activity may be supplied from either the Okha FPSO or a chemical package via a support vessel. Where possible, flushed fluids will return to the Okha FPSO and be processed and treated through the production system. Table 3-7 lists typical discharge volumes during different IMMR activities.

Table 3-7: Typical discharge volumes during different IMMR and subsea activities

Activity	Typical Discharge
Pressure/leak testing and investigation	Investigation initiated if subsea hydraulic consumption is >130 L per day.
Valve functioning	0.5 L to 6 L per valve actuation per Xmas tree and manifold Facility shutdown (cyclone disconnect) ~170 L per shut down across control system (estimated 1-2 shutdowns per year). Standard facility shutdown ~ 170 L per shutdown across control system (estimated 8 – 10 shutdowns per year).
Flushing	Residual hydrocarbon or chemical releases volume depends on injection port size, component geometry, and pumping rates
Hot stab change out	Hydrocarbons or subsea control fluid <10 L.
SCM changeout	Typical releases: acid ~400 L; subsea control fluid ~10 L.
Jumper and umbilical replacement	Typical releases of hydraulic fluid, MEG, and corrosion inhibitor are estimated to be <10 L each
Choke change out	Release of hydrocarbons <10 L and a typical release of MEG is estimated to be 280 L
Flowline or spools repair, replacement, and recovery	Typical release of hydrocarbon or other chemicals depends on equipment configuration and flushing ability. This will be subject to an ALARP determination for the activity, as per normal practice.

3.10.1.7 Marine Growth Removal

Due to the relatively high rate of marine growth on the NWS, excess growth may need to be removed before undertaking many subsea IMMR activities. An ROV or a diver is used for this activity; Table 3-8 lists the different techniques used.

Table 3-8: Marine growth removal methods

Activity / Equipment	Description
Water jetting	Uses HP water to remove marine growth
Brush systems	Uses brushes attached to an ROV to physically remove marine growth
Acid (typically sulfamic acid)	Chemically dissolves calcium deposits

3.10.1.8 Sediment Relocation

If sediment builds up around subsea infrastructure, an ROV-mounted suction pump/dredging unit may be used to move small amounts of sediment in the immediate vicinity (i.e. within the existing footprint). This allows inspection/intervention works to be undertaken. Sediment relocation typically results in minor seabed disturbance and some localised turbidity.

3.10.1.9 Suspend and Preserve Redundant Equipment

If equipment is degraded, damaged, or has deteriorated to a level outside acceptance limits, it may be preserved and suspended on the sea floor until decommissioning.

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4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

In accordance with Regulation 13(2) and 13(3) of the Environment Regulations, this section describes the existing environment that may be affected by the activity (planned and unplanned, as defined in Section 6.6 and described in Section 6.7), including details of the particular relevant values and sensitivities of the environment, which were used for the risk assessment.

4.2 Summary of Key Existing Environment Characteristics

Table 4-1 summarises the key existing environment characteristics, in line with the process of identifying and describing the existing environment in relation to the 'nature and scale' of the activity (refer Section 2.4.2). These key existing environment characteristics are described in terms of the Operational Area and EMBA. The Operational Area describes the key existing environment characteristics and receptors that may be affected by various aspects of the Petroleum Activity Program. The wider EMBA, which has been identified by hydrocarbon spill modelling (Figure 4-1), describes all characteristics and receptors with the potential to be impacted if the worst-case credible hydrocarbon spill scenario occurs (a loss of well containment, described in Section 6.8). Planned activities within the Petroleum Activity Program are not expected to impact receptors within the wider EMBA.

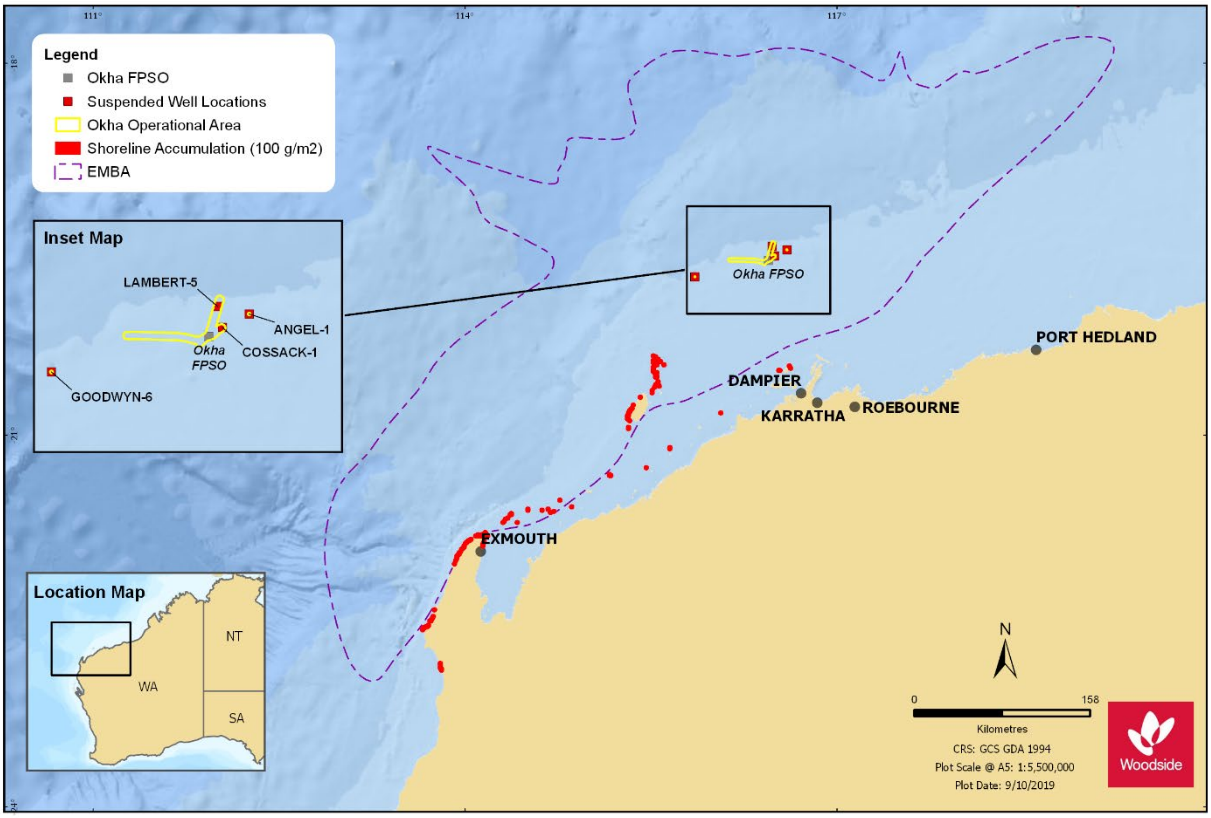

Figure 4-1: Operational Area and EMBA

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Table 4-1: Summary of key existing environment characteristics

Sensitive Receptor		EP Section	Description
Physical Environment	***Climate and Meteorology***	4.4.1	*Operational Area and Wider EMBA* • tropical monsoon climate with hot summers and mild winters • most rainfall occurs during late summer and autumn • seasonal wind patterns with south-westerly winds characterising summer months and easterly winds characterising winter. Winds during transition period between seasons typically more variable • tropical cyclones regularly occur in the region during summer period.
	Oceanography	4.4.2	*Operational Area* • locally generated wind surface currents are superimposed on geostrophic and tidal currents • geostrophic flow characterised by the southward flowing Leeuwin current, which strengthens in late summer and winter • water quality is expected to reflect the offshore oceanic conditions of the North West Shelf Province (NWS Province) and wider region • surface water temperatures are relatively warm, ranging seasonally from ~24.3 to 28.5 °C • offshore waters are expected to be of high quality given the distance from shore and lack of terrigenous inputs. *Wider EMBA* • water quality is regulated by the Indonesian Throughflow (ITF), which plays a key role in initiating the Leeuwin Current and brings warm, low-nutrient, low-salinity water to the North-west Marine Region (NWMR). It is the primary driver of the oceanographic and ecological processes in the NWS Province • variation in surface salinity throughout the year is minimal (35.2 and 35.7 practical salinity units [PSU]) • during summer, the Leeuwin Current typically weakens and the Ningaloo Current develops, facilitating upwelling of cold, nutrient-rich waters up onto the continental shelf • other areas of localised upwelling in the NWMR include the Exmouth Plateau, where seabed topographical features force the surrounding deeper, cooler, nutrient rich waters up into the photic zone • turbidity is primarily influenced by sediment transport by oceanic swells and primary productivity.
	Bathymetry	4.4.3	*Operational Area* • located in waters ~75–130 m deep along the continental shelf • generally flat with gentle gradient. *Wider EMBA* • relatively complex bathymetric features are found at Rankin Bank to the east and Glomar Shoal to the west of the Operational Area • numerous Key Ecological Features (KEFs) associated with bathymetric features in the wider EMBA.

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<table>
<tr><th colspan="2">Sensitive Receptor</th><th>EP Section</th><th>Description</th></tr>
<tr><td rowspan="2"></td><td>Marine Sediment</td><td>4.4.4</td><td>Operational Area
• comprises fine sediments (from muds to sands) of high quality (low levels of contaminants)
• sediments are expected to consist primarily of carbonates.
Wider EMBA
• sediment characteristics change with depth and distance from shore, with sediments becoming progressively finer with increasing depth and distance, particularly beyond continental shelf break.</td></tr>
<tr><td>Air Quality</td><td>4.4.5</td><td>There is limited air quality data for the NWS Province. However, ambient air quality in the Operational Area and wider EMBA is expected to be of high quality.</td></tr>
<tr><td rowspan="5">Habitats</td><td>Critical Habitat – EPBC Listed</td><td>4.5.1.1</td><td>No Critical Habitats or Threatened Ecological Communities, as listed under the EPBC Act, are known to occur within the Operational Area. Refer to the relevant section for each protected species for a description of the critical habitats that may occur within the wider EMBA.</td></tr>
<tr><td>Marine Primary Producers</td><td>4.5.1.2</td><td>Given the water depth, benthic primary producers will not occur within the Operational Area:
<u>Coral Reefs</u>
Wider EMBA
• nearest coral habitat to the Operational Area is Rankin Bank
• coral reef habitats include Glomar Shoal, the Montebello/Barrow/Lowendal Islands Group, Barrow Island and Ningaloo Coast.
<u>Seagrass Beds / Macroalgae</u>
Wider EMBA
• nearest seagrass/macroalgae habitat is widely distributed in coastal waters that receive sufficient light to support seagrass and macroalgae.
<u>Mangroves</u>
Wider EMBA
• broadly distributed in protected coastlines throughout the wider EMBA.</td></tr>
<tr><td>Life Cycle Stages ‘Critical’ Habitats</td><td>4.5.1.3</td><td>Refer to Biologically Important Areas (BIAs) and species descriptions.</td></tr>
<tr><td>Other Communities/ Habitats</td><td>4.5.1.4</td><td><u>Plankton</u>
Operational Area
• plankton communities in the Operational Area are likely to reflect the broader NWS Province.
Wider EMBA</td></tr>
</table>

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Sensitive Receptor		EP Section	Description
			• offshore phytoplankton communities in the NWS Province are characterised by smaller taxa (e.g. bacteria), while shelf waters are dominated by larger taxa (e.g. diatoms) • peak primary productivity along the shelf edge of the Ningaloo Reef occurs in late summer/early autumn. Pelagic and Demersal Fish Populations *Operational Area* • fish communities in the Operational Area comprise small and large species pelagic fish, as well as demersal species associated with subsea infrastructure • Ancient Coastline at 125 m KEF may support demersal fish assemblages. *Wider EMBA* • key demersal fish biodiversity areas are likely to occur in other complex habitats, e.g. coral reefs • relatively complex habitats (e.g. reefs, Rankin Bank, Glomar Shoal) support high demersal fish richness and abundance. Filter Feeders *Operational Area* • filter feeders are generally located in areas with strong currents and hard substratum, and have developed on subsea infrastructure in the Operational Area • low to moderate density filter feeders widely distributed in surveyed portions of Operational Area. *Wider EMBA* • the NWMR has been identified as a sponge diversity hotspot with a variety of areas with high biodiversity, particularly in the Ningaloo Marine Park. Benthic Communities *Operational Area* • sparse assemblages of epifauna and infauna in the Operational Area, including polychaetes and crustaceans. *Wider EMBA* • areas of hard substrate expected to host relatively diverse benthic communities.
Protected Species	***Biologically Important Areas (BIAs)***	4.5.2.3	*Operational Area* • foraging area for the wedge-tailed shearwater during its breeding season (August to April) • whale shark foraging area northward from Ningaloo along the 200 m isobath, with seasonally high use (April to June). *Wider EMBA* • large number of BIAs within wider EMBA.
	Marine Mammals	4.5.2.5	*Operational Area* • sei whale – there are no known key aggregation areas (resting, breeding or feeding) located within the Operational Area

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Sensitive Receptor		EP Section	Description
			• Bryde's whale – tropical and temperate waters, with inshore and offshore morphologies / populations. May be seasonally present between December and June • blue whale – there are no known key aggregation areas (resting, breeding or feeding) located within the Operational Area, however they may be likely to occur • fin whale – there are no known key aggregation areas (resting, breeding or feeding) located within the Operational Area • humpback whale – humpback whales may transit through the Operational Area during their northbound and southbound migrations (although typically occur inshore of the Operational Area), likely between June and September (including northbound and southbound migration) • sperm whale – unlikely to occur in Operational Area due to preference for oceanic waters • Antarctic minke whale – migrates up to 20 °S for feeding and possible breeding. Unlikely to occur within Operational Area • southern right whale – unlikely to occur in Operational Area • killer whale, orca – no recognised key localities, expected to rarely occur. *Wider EMBA* • a range of migratory cetacean species occur, including several dolphin species • resident coastal populations of small cetacean species • dugong – known to occur in tropical coastal environments where seagrasses occur, including Ningaloo Marine Park • Antarctic minke whale – migrates up to 20 °S for feeding and possible breeding. Unlikely to occur within Operational Area but may occur in wider EMBA • southern right whale – unlikely to occur in Operational Area, may occur in southern extent of EMBA.
	Marine Turtles	4.5.2.6	*Operational Area* • the Operational Area does not contain any known critical habitat or BIAs for any species of marine turtle • presence of the five species of threatened marine turtles (loggerhead, green, leatherback, hawksbill and flatback) within the Operational Area is likely to be infrequent and limited to individuals or small numbers transiting, as they seasonally move in and out of key foraging, internesting and nesting locations • given benthic habitat present at Glomar Shoal, marine turtles may forage within more shallow areas of the KEF (i.e. outside the Operational Area); however, this is not a known foraging location or listed BIA. *Wider EMBA* • green, loggerhead, flatback and hawksbill turtles have significant nesting rookeries on beaches along the Montebello/Barrow/Lowendal Islands Group, Ningaloo coast and the Muiron Islands. Leatherback turtles may occur within the wider EMBA but there are no known nesting beaches in WA • marine turtles may forage in shallow waters on the continental shelf, including Rankin Bank.

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Sensitive Receptor		EP Section	Description
	Sea Snakes	4.5.2.6	*Operational Area* • given the offshore location and deeper water depths of the Operational Area, sea snake sightings will likely be infrequent and comprise a few individuals but may be more prevalent within the Operational Area. *Wider EMBA* • sea snakes frequent the waters of the continental shelf and around offshore islands.
	Fishes and Elasmobranchs	4.5.2.7	*Operational Area* • the EPBC Act Protected Matters Search Tool (PMST) identified ten species of Threatened and/or Migratory sharks (grey nurse shark, great white shark, green sawfish, whale shark, narrow sawfish, shortfin mako, longfin mako, reef manta ray, giant manta ray and green sawfish) that may occur in the Operational Area • the Operational Area overlaps the whale shark foraging BIA (although it may constitute part of the migration corridor for animals moving to and from annual aggregation off Ningaloo Reef). *Wider EMBA* • whale sharks are known to aggregate annually, from March to July, in areas off Ningaloo Reef and North West Cape. After the aggregation period, the distribution of the whale sharks is largely unknown but surveys suggest that the group disperses widely and up to 1800 km away to areas in Indonesia, Christmas Island and Coral Sea • Ningaloo Reef is an important area for giant and reef manta rays in autumn and winter, and they are known to occur in tropical waters throughout the wider EMBA • grey nurse sharks are likely to be found in shallow waters of the wider EMBA • sawfish may occur in shallow coastal habitats • great white sharks, shortfin makos and longfin makos are all known to occur within the wider EMBA • porbeagle shark may occur in temperate waters in the southern portion of the wider EMBA.
	Birds	4.5.2.8	*Operational Area* • ten species of Threatened and/or Migratory bird species (red knot, eastern curlew, common noddy, streaked shearwater, lesser frigatebird, great frigatebird, common sandpiper, sharp-tailed sandpiper, pectoral sandpiper, and osprey) were identified as potentially occurring within the Operational Area. No critical habitat associated with these species has been identified within the Operational Area • a BIA for wedge-tailed shearwater, during their breeding season, overlaps the Operational Area. *Wider EMBA* • several BIAs (key breeding/nesting, roosting, foraging and resting areas) for seabirds and migratory shorebirds occur in the wider EMBA, including areas on the islands of the Montebello/Barrow/Lowendal Islands group, Pilbara Islands, Ningaloo Coast and Muiron Islands.

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<table>
<tr><th colspan="2">Sensitive Receptor</th><th>EP Section</th><th>Description</th></tr>
<tr><td rowspan="3">Socioeconomic</td><td>Cultural Heritage</td><td>4.6.1</td><td><u>Operational Area</u>
• there are no known sites of Indigenous or European cultural or heritage significance within or in the vicinity of the Operational Area.
<u>Wider EMBA</u>
• Barrow Island, Montebello Islands, Dampier Archipelago, Ningaloo Reef and the adjacent foreshore contain numerous registered Indigenous heritage sites
• the closest recorded Maritime Cultural Heritage sites to the Operational Area are the McCormack and McDermott Derrick Barge No. 20 shipwrecks, both ~47 km south of the Operational Area
• World Heritage Areas (WHAs) include the Ningaloo Coast WHA
• National Heritage listed and proposed places include Barrow Island, Montebello Islands, Dampier Archipelago and Ningaloo Coast
• Commonwealth Heritage listed places include the Ningaloo Marine Area – Commonwealth Waters.</td></tr>
<tr><td>Ramsar Wetlands</td><td>4.6.2</td><td>No Ramsar wetlands occur in the Operational Area or wider EMBA.</td></tr>
<tr><td>Fisheries – Commercial</td><td>4.6.3</td><td>Operational Area
There are a number of Commonwealth and State fisheries designated management areas that overlap the Operational Area; however, only the State Pilbara Demersal Scalefish Fishery is expected to be active within the Operational Area:
• Commonwealth fisheries:
– Southern Bluefin Tuna Fishery
– Western Skipjack Tuna Fishery
– Western Tuna and Billfish Fishery
• State fisheries:
– Pilbara Demersal Scalefish Fishery
– West Coast Deep Sea Crustacean Managed Fishery
– Nickol Bay Prawn Managed Fishery
– Onslow Prawn Managed Fishery
– Pearl Oyster Managed Fishery
– Marine Aquarium Fish Managed Fishery
– Western Australian Abalone Fishery
– Mackerel Managed Fishery
– South West Coast Salmon Managed Fishery</td></tr>
</table>

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Sensitive Receptor		EP Section	Description
			• there are no aquaculture activities within or adjacent to the Operational Area. *Wider EMBA* • a number of State and Commonwealth fisheries overlap the EMBA.
	Fisheries – Traditional	4.6.4	There are no known traditional or customary fisheries within or adjacent to the Operational Area. Traditional fisheries are typically restricted to shallow coastal waters and/or areas with structure such as reef. Ningaloo Coast, Barrow Island and Montebello Islands and the adjacent foreshores have a known history of fishing, when areas were occupied (as identified from historical records). Traditional fishing still occurs within coastal waters of the Dampier Archipelago.
	Tourism and Recreation	4.6.5	*Operational Area* • tourism activities in the Operational Area are not known to occur due to water depths and distance offshore. *Wider EMBA* • recreational fishing is expected to occur throughout wider EMBA, primarily in continental shelf waters including Rankin Bank • the Ningaloo Marine Park and Montebello Islands are popular for marine nature-based tourist activities.
	Shipping	4.6.6	*Operational Area* • several shipping fairways overlap the Operational Area. *Wider EMBA* • the coastal and offshore waters of the region support significant commercial shipping activity, most of which is associated with the mining and oil and gas industries • major shipping routes are associated with entry to the ports of Barrow Island, Dampier, Onslow and Port Hedland.
	Oil and Gas Infrastructure	4.6.7	*Operational Area* • GWA is 22 km south-west of the Operational Area and 54 km from the Okha FPSO • NRC lies within the western extremity of the Operational Area and Angel overlaps the Angel-1 suspended exploration well section of the Operational Area. These facilities are 32 and 20 km from the Okha FPSO, respectively. *Wider EMBA* • there are numerous petroleum titles surrounding the Operational Area • several fixed platforms are located near the Operational Area, including GWA, Pluto, Angel, Wheatstone, and Reindeer.
	Defence	4.6.8	There are designated defence practice areas in the offshore marine waters off Ningaloo Reef and the North West Cape, beyond the Operational Area.

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Sensitive Receptor		EP Section	Description
Values and Sensitivities	***Montebello / Barrow / Lowendal Islands***	4.7.1	Protected areas in this locality include: • Montebello AMP • Montebello Islands Marine Park, Barrow Island Marine Park, Barrow Island Marine Management Area • Barrow Island Nature Reserve • Lowendal Islands Nature Reserve.
	Ningaloo Coast and Gascoyne	4.7.2	Protected areas in this locality include: • Ningaloo Coast WHA and National Heritage Area • Ningaloo AMP • Ningaloo Marine Park and Muiron Islands Marine Management Area • Gascoyne AMP.
	Pilbara Coast and Islands	4.7.3	Protected areas in this locality include: • Dampier AMP Sensitive areas in this locality include: • Dampier Archipelago State Nature Reserve • Dampier Archipelago National Heritage Place • Pilbara Islands (north group) • Pilbara Islands (middle group) • Pilbara Islands (south group).
	Rowley Shoals	4.7.4	Protected areas in this locality that overlap the Operational Area include: • Argo-Rowley Terrance AMP.
	Key Ecological Features	4.7.5	*Operational Area* • Ancient Coastline at 125 m Depth Contour. *Wider EMBA* • A number of KEFs occur within the wider EMBA.
	Other Sensitive Areas	4.7.6	Rankin Bank lies ~21 km west of the Operational Area at the closest point (i.e. from the Goodwyn-6 suspended exploration well section of the Operational Area).

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4.3 Regional Context

The Operational Area is located in Commonwealth Waters within the NWS Province, in water depths of ~75–130 m. The NWS Province is part of the wider NWMR (Figure 4-1) as defined under the Integrated Marine and Coastal Regionalisation of Australia (National Oceans Office and Geoscience Australia 2005). The NWS Province encompasses the continental shelf between North West Cape and Cape Bougainville, and varies in width from ~50 km at Exmouth Gulf to >250 km off Cape Leveque and includes water depths of 0–200 m (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2012a).

The NWS Province is characterised by these biophysical features (DSEWPaC 2012a):

- Transitional climatic conditions, between dry tropics to the south and humid tropics to the north.
- Strong seasonal winds and moderate offshore tropical cyclone activity.
- Surface waters are tropical year-round and highly stratified during summer months (thermoclines occur at water depths between 30 and 60 m). In winter, surface waters are well mixed, with thermoclines occurring deeper around 120 m depth.
- Surface ocean circulation is strongly influenced by the 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 comprises sediments that generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the slope and abyssal plain. Approximately 60–90% of the sediments in the region are carbonate derived (Brewer et al. 2007). The distribution and resuspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic cyclones. Further offshore, on the mid to outer shelf and on the slope, sediment movement is primarily influenced by ocean currents and internal tides, the latter causing resuspension and net downslope deposition of sediments (Baker et al. 2008).
- The region has high species richness but a relatively low level of endemism (i.e. species particular to the region in comparison to other areas of Australian waters). Furthermore, most of the region’s species are tropical and are recorded in other areas of the Indian Ocean and western Pacific Ocean.
- Benthic communities within the region range from nearshore benthic primary producer habitats such as seagrass beds, coral communities and mangroves to offshore soft sediment seabed habitats associated with low density sessile and mobile benthos such as sponges, molluscs and echinoids (with noted areas of sponge hotspot diversity).
- Internationally significant migratory routes, resident populations, breeding and/or feeding grounds for a number of EPBC Act listed threatened and migratory marine species, including humpback whales, marine turtles, whale sharks, seabirds and migratory shorebirds, are present.

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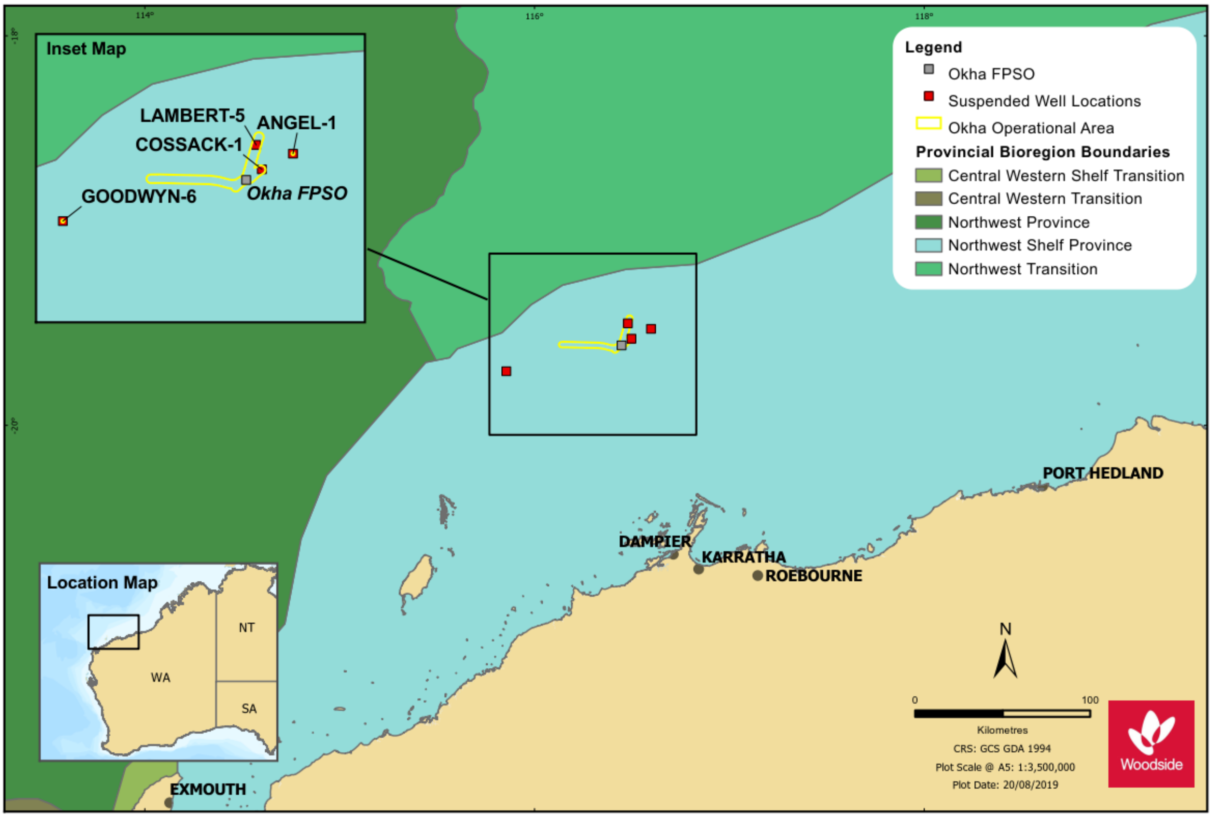

Figure 4-2: NWMR and the location of the Operational Area

4.4 Physical Environment

4.4.1 Climate and Meteorology

4.4.1.1 Seasonal Patterns

The Operational Area experiences a tropical monsoon climate, with distinct wet (October to April) and dry (May to September) seasons (Pearce et al. 2003). Rainfall in the region typically occurs during the wet season, with highest falls observed during late summer (Bureau of Meteorology [BoM] n.d.) and is often associated with the passage of tropical low-pressure systems and cyclones (Pearce et al. 2003). Rainfall outside this period is typically low (Figure 4-3).

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Air temperatures in the region, as measured at Karratha Aerodrome, follow seasonal trends (Figure 4-3). Maximum temperatures during summer reach an average of 36 °C in January, falling to an average maximum of 26 °C in July. Average minimum temperatures range from 26 °C in January to 14 °C in July.

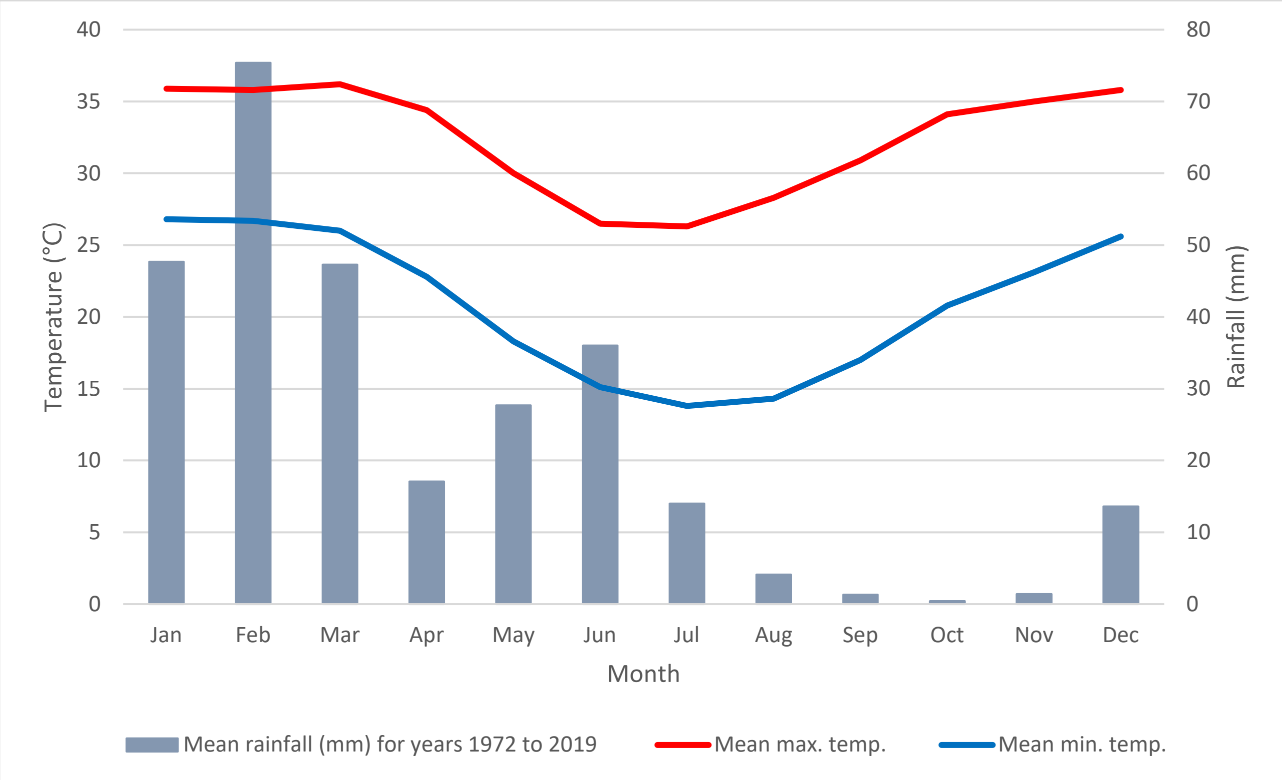

Figure 4-3: Mean monthly maximum temperature, minimum temperature and rainfall from Karratha Aerodrome meteorological station from January 1993 to June 2019

Source: BoM (n.d.)

4.4.1.2 Wind

Winds typically vary seasonally, with a tendency for winds from the south-westerly quadrant during summer and the south-easterly quadrant in winter (Figure 4-4). The summer south-westerly winds are driven by high-pressure cells that pass from west to east over the Australian continent. During winter months, the relative position of the high-pressure cells moves further north, leading to prevailing south-easterly winds blowing from the mainland (Pearce et al. 2003). Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, typically April and August (Figure 4-4).

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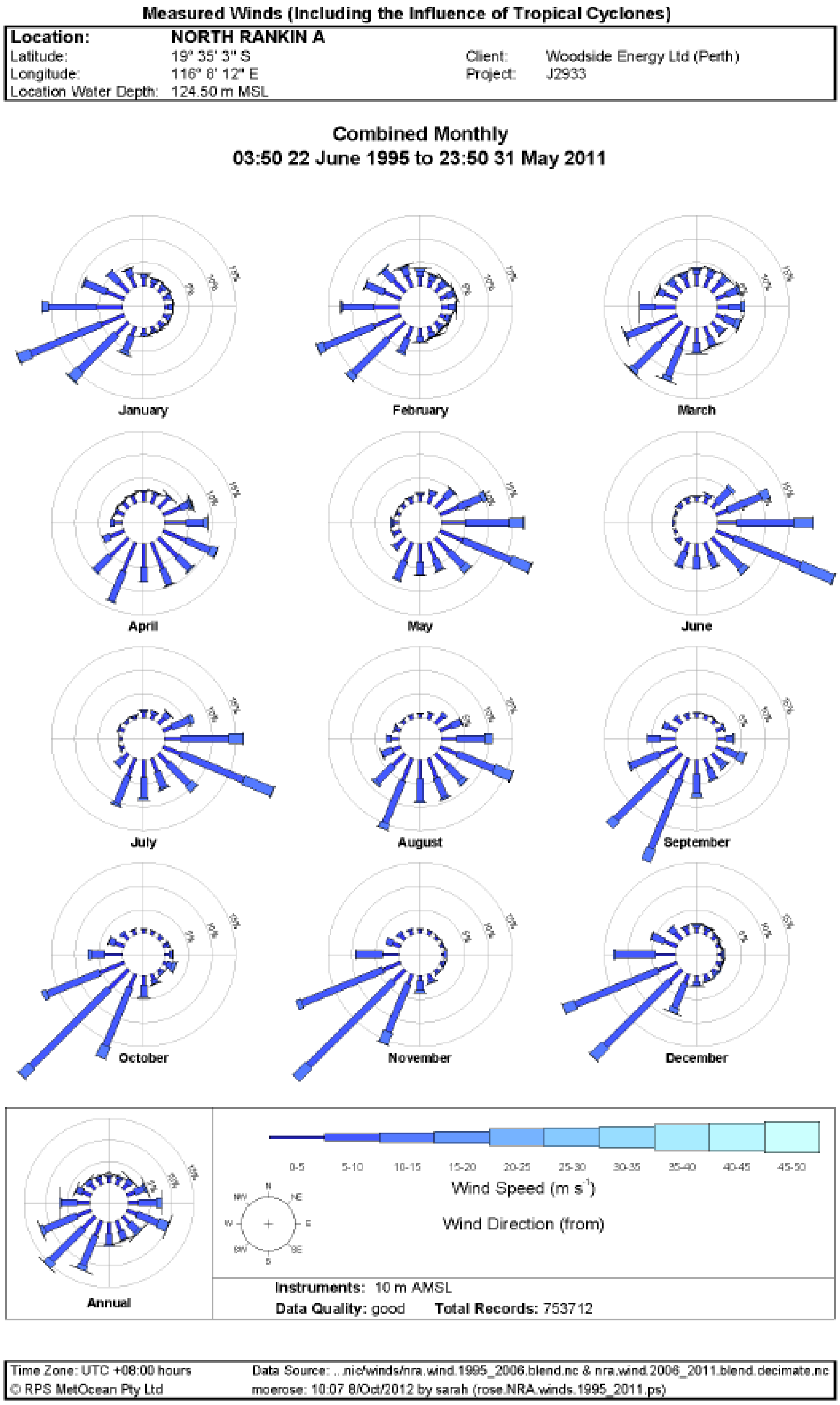

Figure 4-4: NWS monthly and annual wind roses derived from NRC measured 1995–2011 wind data

4.4.1.3 Tropical Cyclones

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Cyclones are a relatively frequent event in the region (Figure 4-5), with the Pilbara coast experiencing more cyclonic activity than most other regions of the Australian mainland coast (BoM n.d.). The cyclone season officially runs from November to April each year, although cyclones also occur outside this period (BoM n.d.). Significant storm surge is associated with the passage of a cyclone, which can result in very high tides and coastal flooding (BoM n.d., Pearce et al. 2003).

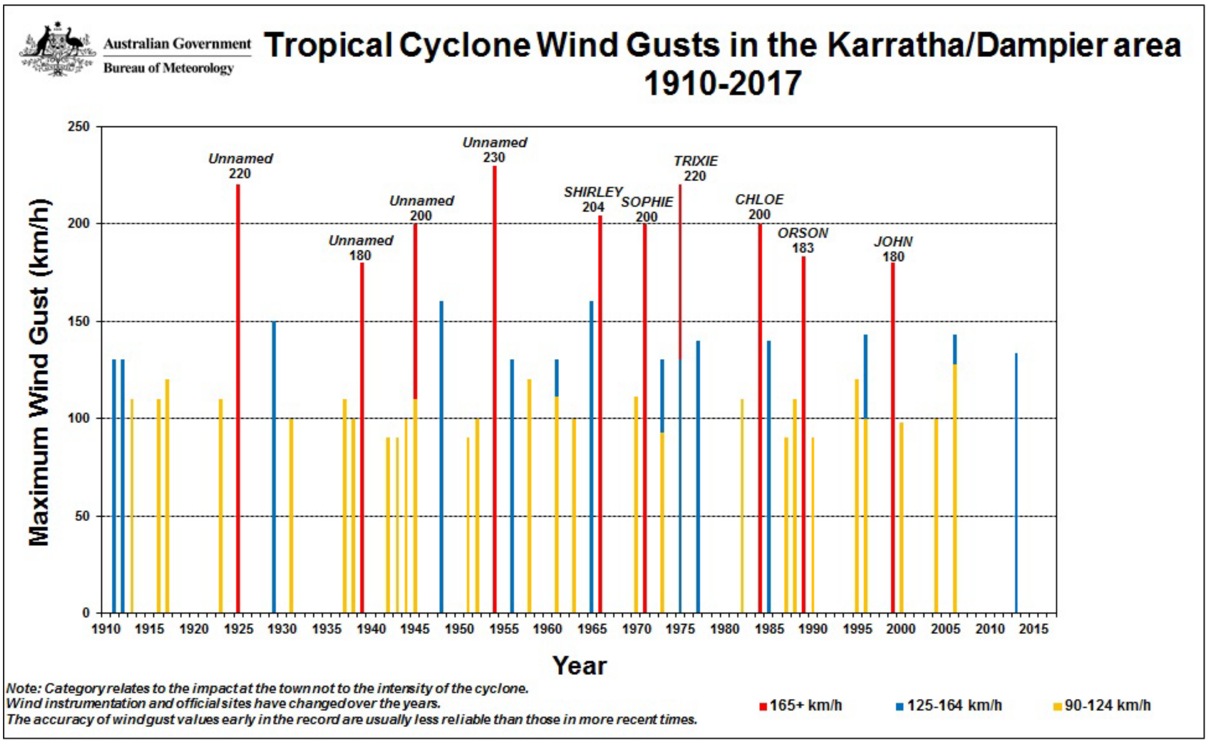

Figure 4-5: Tropical cyclone activity in the Dampier/Karratha region 1910–2017

Source: BoM (n.d.)

4.4.2 Oceanography

4.4.2.1 Currents and Tides

Currents in the region comprise local currents driven by winds and tides, superimposed on geostrophic currents. Local winds generate stress on the water surface, forcing the surface layer in the general direction of wind movement, but with an offset (15–45%) in an anti-clockwise direction (Coriolis Effect). In the open ocean, sustained winds result in wind-forced currents of ~3% of the wind speed (Holloway and Nye 1985). Thus, a sustained wind of 20 knots may force surface currents of up to 0.6 knots. Wind patterns in the region are described in Section 4.4.1.2 and shown in Figure 4-4.

The large-scale ocean circulation of the NWMR (Figure 4-6) is primarily influenced by the ITF (Meyers et al. 1995, Potemra et al. 2003), and the Leeuwin Current (Batteen et al. 1992, Godfrey and Ridgway 1985, Holloway and Nye 1985, James et al. 2004, Potemra et al. 2003). Both currents are significant drivers of the NWMR ecosystems. The currents are driven by pressure differences between the equator and the higher density cooler and more saline waters of the Southern Ocean, strongly influenced by seasonal change and El Niño and La Niña episodes (DSEWPaC 2012a). The ITF and Leeuwin Current are strongest during late summer and winter (Holloway and Nye 1985, James et al. 2004). Flow reversals to the north-east associated with strong south-westerly winds are typically weak and short-lived, but can generate upwelling of cold deep water onto the shelf (Condie et al. 2006, Holloway and Nye 1985, James et al. 2004).

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The Leeuwin Current flows southward along the edge of the continental shelf and is primarily a surface flow (up to 150 m deep). The Ningaloo Current flows in the opposite direction to the Leeuwin Current, running northward along the outside of Ningaloo Reef and across the inner shelf from September to mid-April (Figure 4-6). In March, on the termination of the Northwest Monsoon, an ‘extended Leeuwin Current’, currently known as the Holloway Current, develops, flowing to the south-east along the NWS (DSEWPaC 2012a).

In addition to the geostrophic current dynamics, tidally driven currents are a significant component of water movement in the NWMR. Wind-driven currents become dominant during the neap tide (Pearce et al. 2003). In summer, the stratified water column and large tides can generate internal waves over the upper slope of the NWMR (Craig 1988). As these waves pass the shelf break at ~125 m depth, the thermocline may rise and fall by up to 100 m in the water column (Holloway 1983, Holloway and Nye 1985). Internal waves of the NWMR are confined to water depths between 70 m and 1000 m and the dissipation energy from such waves can enhance mixing in the water column (Holloway et al. 2001).

Tides in the NWMR are semidiurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards the north-west (Pearce et al. 2003). The NWMR exhibits a considerable range in tidal height, from microtidal ranges (<2 m) south-west of Barrow Island to macrotidal ranges (>6 m) north of Broome (Brewer et al. 2007, Holloway 1983). Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights (Pearce et al. 2003).

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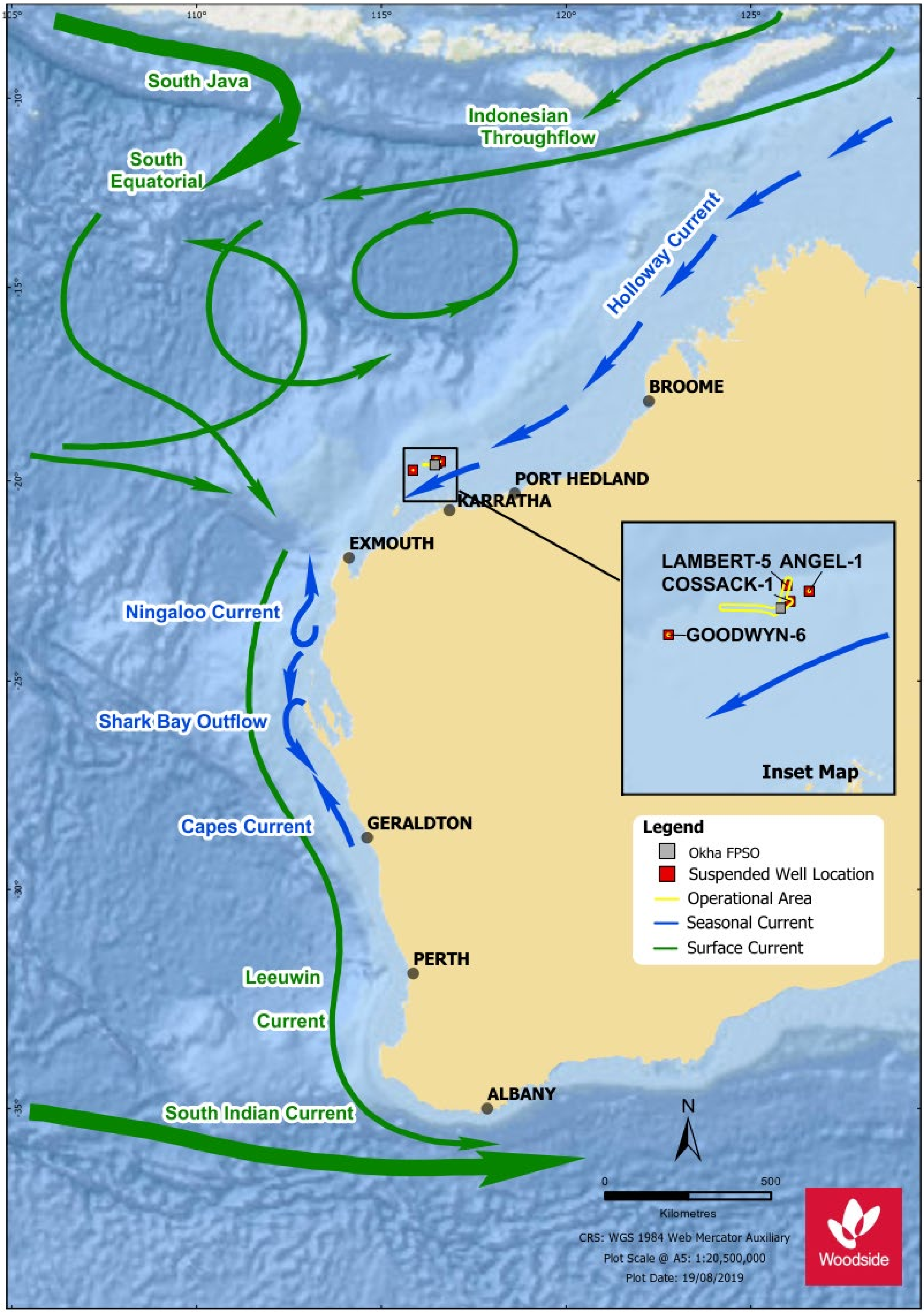

Figure 4-6: Large-scale ocean circulation of the NWMR including the location of the ITF and other currents of significance

Source: Department of the Environment, Water, Heritage and the Arts (DEWHA) 2008

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4.4.2.2 Wave Height

Datawell waverider buoys measured wave height from 1993 to 2005 near the Pluto platform (~92 km south-west of the Operational Area), recording a maximum measured non-cyclonic significant wave height of 6.2 m and a combined non-cyclonic and cyclonic maximum wave height of 11.4 m.

Waves within the NWS Province reflect the direction of the synoptic winds and flow predominantly from the south-west in the summer, and from the east in winter (Pearce et al. 2003). Only 10% of significant wave heights off Dampier exceed 1.2 m, with the average wave height being 0.7 m (Pearce et al. 2003). Storms and cyclones may generate swells up to 8.0 m high (Pearce et al. 2003).

4.4.2.3 Seawater Characteristics

The offshore, oceanic seawater characteristics of the NWS Province exhibit seasonal and water depth variation in temperature and salinity, greatly influenced by major currents in the region (see Section 4.4.2). Surface waters are relatively warm year round due to the tropical water supplied by the ITF and the Leeuwin Current, with temperatures reaching 30 °C in summer and dropping to 22 °C in winter (Pearce et al. 2003). Near seabed temperatures in deeper waters (>120 m water depth) are less variable, with temperatures averaging 22–24 °C year round.

During summer, the water column is thermally stratified due to surface heating, with the thermocline occurring between 50 m and 100 m water depth, indicating surface waters are well mixed within the Operational Area (BMT Oceanica 2015a, James et al. 2004). Surface waters are also relatively well mixed in winter due to a weaker thermal gradient and persistent south-easterly winds promoting mixing, with the thermocline occurring at around 120 m depth (DSEWPaC 2012a, James et al. 2004).

Seawater temperature records at the Pluto platform (~92 km south-west of the Operational Area at the closest point) over a period of 13 months from December 2005 to January 2007 show surface waters reach their maximum average temperatures in March and April (average ~28.5 °C) and are coolest in August, September and October (average ~24.3 °C) (BMT Oceanica 2015a, Woodside Energy 2006).

Variation in surface salinity along the NWS (adjacent to the Northwest Province) throughout the year is minimal (between 35.2 and 35.7 PSU), with slight increases occurring during the summer months due to intense coastal evaporation (James et al. 2004, Pearce et al. 2003). This small increase in salinity during summer is then countered by the arrival of the lower-salinity waters of the Leeuwin Current and ITF in autumn and winter (James et al. 2004).

Turbidity is primarily influenced by sediment transport by oceanic swells and primary productivity (Pearce et al. 2003). Upwelling of nutrient-rich waters may increase phytoplankton productivity in the photic zone, which may increase local turbidity (Wilson et al. 2003). In nearshore areas, turbidity is highly variable due to storm run-off, wind-generated waves and large tidal ranges (Pearce et al. 2003). Periodic events, such as major sediment transport associated with tropical cyclones, may influence turbidity on a regional scale (Brewer et al. 2007).

Water quality in the NWMR within the wider EMBA is regulated by the ITF, a low-salinity water mass that plays a key role in initiating the Leeuwin Current (DSEWPaC 2012a). It brings warm, low-nutrient, low-salinity water from the western Pacific Ocean through the Indonesian Archipelago to the Indian Ocean. It is the primary driver of the oceanographic and ecological processes in the region (DEWHA 2008). South of the NWMR, the Leeuwin Current continues to bring warm, low-nutrient, low-salinity water further south. Eddies formed by the Leeuwin Current transport nutrients and plankton communities offshore (DEWHA 2008). During summer, the Leeuwin Current typically weakens and the Ningaloo Current develops, facilitating upwellings of cold, nutrient-rich waters up onto the NWS (DSEWPaC 2012a). Other areas of localised upwelling in the NWMR include the Wallaby Saddle and Exmouth Plateau, where these seabed topographical features force the surrounding deeper, cooler, nutrient-rich waters up into the photic zone (DSEWPaC 2012a).

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4.4.3 Bathymetry

The Operational Area lies in waters ~75 to 130 m deep on the continental shelf (Figure 4-6). The bathymetry within the Operational Area is generally flat, which is consistent with the broader NWS Province shelf region (Baker et al. 2008). The seabed has a gentle (0.05°) seaward gradient, extending to a relatively steep outer slope ~200 to 300 km offshore in water depths of around 200 m (Dix et al. 2005). The continental slope then descends more rapidly from the shelf edge to depths >1000 m to the north-west (James et al. 2004).

A section of the Ancient Coastline at 125 m Depth Contour KEF overlaps the Operational Area. Areas of this KEF comprise rocky hard substrate, which may occur within the Operational Area; however, the portion of the KEF that overlaps the Operational Area is predominantly made up of soft sediment.

Glomar Shoal is a shallow sedimentary bank comprising coarser biogenic material than the surrounding seabed and has been defined as a KEF within the NWMR. The shoal reaches to within 26–70 m of the sea surface (Falkner et al. 2009) and is ~3 km south-east of the Operational Area at the nearest point (i.e. from the Angel-1 suspended exploration well section of the Operational Area) and ~14 km from the Okha FPSO.

Rankin Bank is a sedimentary bank located on the continental shelf ~21 km east of the Operational Area at the nearest point (i.e. from the Goodwyn-6 suspended exploration well section of the Operational Area) and ~87 km from the Okha FPSO. The bank rises from around 40–50 m to 18 m from the sea surface.

Refer to Section 4.7 for information on the environmental values of Rankin Bank and Glomar Shoal.

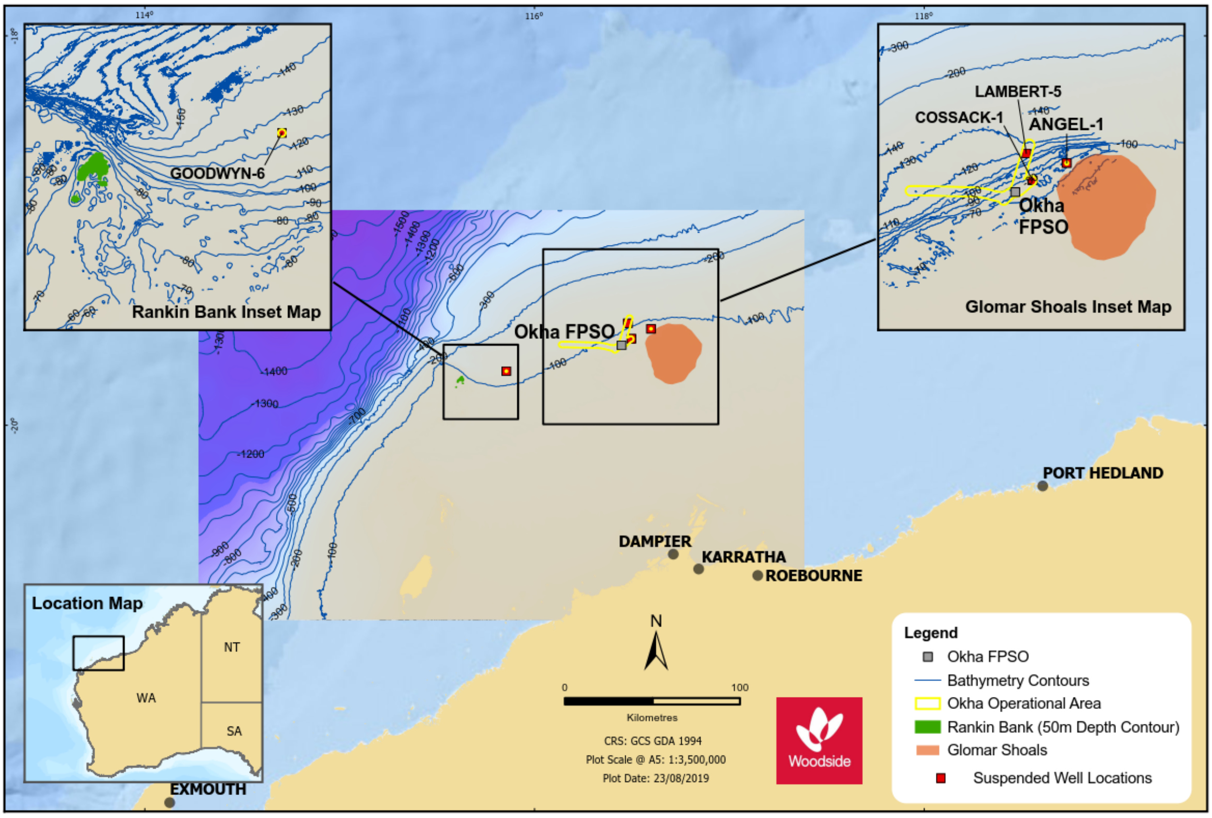

Figure 4-7: Bathymetry and seabed features of the Operational Area

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4.4.4 Marine Sediment

Sediments in the Operational Area are expected to be broadly consistent with those in the NWS Province, and can be inferred from Woodside sampling programs undertaken at Glomar Shoal and the GWA (Australian Institute of Marine Science [AIMS] 2014a, BMT Oceanica 2015a). The sediments in the Operational Area are expected to comprise primarily fine sands, very fine sands and silt, similar to those analysed at Glomar Shoal and GWA, ~3 km and 22 km from the Operational Area at the closest points, respectively (AIMS 2014a, BMT Oceanica 2015a).

Sediments in the outer NWS Province are relatively homogenous and are typically dominated by sands and a small portion of gravel (Baker et al. 2008). Fine sediments (e.g. muds) increase with proximity to the shoreline and the shelf break but are less prominent in the intervening continental shelf (Baker et al. 2008). Carbonate sediments typically account for the bulk of sediment composition, with both biogenic and precipitated sediments present on the outer shelf (Dix et al. 2005). Beyond the shelf break, the proportion of fine sediments increases along the continental slope towards the Exmouth Plateau and the abyssal plain (Baker et al. 2008).

While hard substrates are not known to occur within the Operational Area, they occur in the region more broadly and can host more diverse benthic communities. Hard substrate may be associated with the Ancient Coastline at 125 m Depth Contour KEF (Section 4.7.6).

4.4.5 Air Quality

There is a lack of air quality data for the offshore NWMR airshed. Studies have been undertaken for the nearshore Pilbara environment to monitor known sources of potential air pollution for locations such as the Burrup Peninsula and Port Hedland, but no monitoring is undertaken offshore.

Due to the extent of the open ocean area and the activities that are currently undertaken, Woodside considers that the ambient air quality in the Operational Area and wider offshore NWMR will be high.

4.5 Biological Environment

4.5.1 Habitats

4.5.1.1 Critical Habitat – EPBC Listed

No Critical Habitats or Threatened Ecological Communities, as listed under the EPBC Act, occur within the Operational Area, as indicated by the EPBC Act PMST report based on the Operational Area and wider EMBA, which is provided in Appendix C.

4.5.1.2 Marine Primary Producers

Seafloor communities in deeper shelf waters receive insufficient light to sustain ecologically sensitive primary producers such as seagrasses, macroalgae or zooxanthellate corals. These benthic primary producer groups will not occur in the Operational Area given the depth of water (between ~75 and 130 m).

Benthic primary producer habitats are widespread within the EMBA in relatively shallow waters (typically <30 m water depth), such as the mainland coast, offshore islands, reefs and sedimentary banks.

Coral Reef

Coral reef habitats are an integral part of the marine environment; these habitats have a high diversity of corals, associated fish and other species of both commercial and conservation importance. Coral communities on the middle to outer continental shelf in the region are typically mesophotic and hence are restricted to benthic habitats receiving sufficient photosynthetically active radiation (PAR) to support zooxanthellate corals (Wahab et al. 2018). Turbidity strongly influences PAR reaching the

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seabed, with less-turbid areas supporting zooxanthellate corals to greater depths (Wahab et al. 2018). Notable coral habitat within the wider EMBA includes, but is not limited to (approximate distance and direction from the closest point of the Operational Area in brackets):

- Glomar Shoal (3 km south-east to KEF boundary)
- Rankin Bank (21 km east)
- Dampier Archipelago (90 km south to State National Heritage Place)
- Montebello Island group (73 km south-west to State Marine Park)
- Barrow Island and Lowendal Island group (94 km south-west to Marine Management Area)
- Ningaloo Coast (incl. Muiron Islands) (259 km south-west to WHA)
- Rowley Shoals (317 km to nearest State Marine Park).

Encrusting corals were the most commonly observed hard coral morphology at both Rankin Bank and Glomar Shoal, with other morphologies (e.g. branching, foliose) less common (Wahab et al. 2018).

Hard corals in the region typically have a distinct spawning season, with most species spawning during autumn (March/April) (Rosser and Gilmour 2008, Simpson et al. 1993). Further information on environmentally sensitive locations with coral reef habitats is provided in Section 4.7.

Seagrass Beds/Macroalgae

Seagrass beds and benthic macroalgae reefs are a main food source for many marine species and provide key habitats and nursery grounds (Heck Jr. et al. 2003, Wilson et al. 2010). In the northern half of WA, these habitats are restricted to sheltered and shallow waters due to large tidal movement, high turbidity, large seasonal freshwater run-off and cyclones. Seagrass beds and macroalgae habitats are widely distributed in shallow coastal waters in the wider EMBA that receive sufficient light. Further information on locations with seagrass and macroalgae habitats is provided in Section 4.7.

Mangroves

Mangroves provide complex structural habitats that act as nurseries for many marine species as well as nesting and feeding sites for many birds, reptiles and insects (Robertson and Duke 1987). Mangroves also maintain sediment, nutrients and water quality within coastal environments, and reduce coastal erosion. The closest coastal habitats to the Operational Area are found 73 km south-west at the Montebello Islands. Mangroves are located in the wider EMBA on offshore islands (Montebello Islands, Barrow Island) and sections of the coastline including large extents of the Pilbara mainland coast (outside the EMBA) and isolated sections of the Ningaloo Coast. Further information on sensitive locations with mangroves is provided in Section 4.7.

4.5.1.3 Lifecycle Stages and Critical Habitats

Spawning, Nursery, Resting and Feeding Areas

Critical habitats for species conservation include spawning, nursery, resting and feeding areas. These critical habitats will vary for each species. Any critical habitat for protected species within the Operational Area, as identified by the EPBC Act PMST (Appendix C), is outlined below in Section 4.5.2 within the relevant species sections, or within Section 4.7.

Migration Corridors

Many marine species, including cetaceans, whale sharks, and migratory seabirds and shorebirds, migrate seasonally between feeding, breeding and nursery habitats through the use of migration

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corridors. Any migration corridor for a protected species that passes through or close to the Operational Area, or within other nearby areas (including the EMBA), is outlined in Section 4.5.2. within the relevant species and BIA subsections.

4.5.1.4 Other Communities/Habitats

Plankton

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

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

Pelagic and Demersal Fish Populations

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

Similar to survey findings at GWA, the presence of subsea infrastructure associated with the Okha FPSO has likely resulted in the development of demersal fish communities that would otherwise not occur in the Operational Area (McLean et al. 2017). The type and abundance of fish present is expected to be highly variable and depend on the relative position of infrastructure on the seabed. For example, partially buried pipelines do not appear to provide the same habitat complexity and opportunity that suspended or resting pipelines provide (McLean et al. 2017). Fish assemblages and colonising invertebrate habitats on artificial hard substrates have also been found to vary with depth and age of the infrastructure. Generally, the structures located in shallower water (<135 m) had a greater diversity of fish compared to habitats at 350 m depth, where the number of fish species and abundance declined markedly (McLean et al. 2018). A study by Bond et al. (2018) confirmed that, compared to adjacent natural seabed habitats, fish fauna associated with pipelines were characterised by higher relative abundance and biomass of commercially important species.

Given the Operational Area is within continental shelf waters, pelagic species are expected to be present. The Ancient Coastline at 125 m Depth Contour KEF overlaps a small portion of the Operational Area, and includes areas of hard substrate that may support relatively diverse demersal fish assemblages. The Glomar Shoal KEF and Rankin Bank (3 km south-east and 21 km east of the Operational Area, respectively) have also been identified as supporting high demersal fish richness and abundance (Wahab et al. 2018). The Continental Slope Demersal Fish Communities KEF is located ~40 km west of the Operational Area at the closest point. Further information on these KEFs, Rankin Bank and Glomar Shoal is provided in Section 4.7.

Filter Feeders

Filter feeders such as sponges, ascidians, soft corals and gorgonians are animals that feed by actively filtering suspended matter and food particles from water by passing the water over

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specialised filtration structures (DEWHA 2008). Filter feeders generally live in areas that have strong currents and hard substratum and are closely associated with substrate type, with areas of hard substrate typically supporting more diverse epibenthic communities (Heyward et al. 2001). Filter feeder communities within the Operational Area are expected to be associated with areas of hard substrate, including development infrastructure, and which may also occur within areas of the Glomar Shoal and Ancient Coastline at the 125 m Depth Contour KEFs where there is hard substrate for attachment.

In 2013, Woodside engaged AIMS to conduct a biodiversity survey of Glomar Shoal and Rankin Bank (AIMS 2014b). In the study, biota data was collected using underwater towed cameras. The survey observed widespread filter feeder habitat throughout the survey area, generally at low to moderate densities. Filter feeding communities included bryozoans, sponges, gorgonians and hydroids attached to consolidated substrate; these were interspersed with sand which hosted few filter feeders (AIMS 2014b).

Sponges and mixed sponge benthic groups were the dominant benthic group at Glomar Shoal, with hard corals, algae, soft corals and mixed benthos only making up 10% of the study area (AIMS 2014b). In contrast, Rankin Bank has almost equal areas of hard corals, soft corals and sponges (AIMS 2014b). The study indicated that both areas had characteristic transitions in habitat types with depth, from shallow hard coral and associated algae groups to deeper soft coral areas with sponges (AIMS 2014b).

Further surveys were undertaken of an area south-east of Rankin Bank (AIMS 2014c). This study focused on an area covering ~100 km^2 of seabed, extending from the outer flank of Rankin Bank across the adjacent shelf at depths of 60 to 100 m. Filter feeding communities included bryozoans, sponges, gorgonians and hydroids attached to consolidated substrate; these were interspersed with sand which hosted few filter feeders (AIMS 2014c).

Discrete areas of hard substrate hosting sessile filter-feeding communities may be associated with the Ancient Coastline at the 125 m Depth Contour KEF, which overlaps the Operational Area. Falkner et al. (2009) concluded the Ancient Coastline may not represent different habitat type compared to the surrounding areas and suggested that associated faunal communities may be similar.

The Montebello AMP is located ~35 km south-west of the Operational Area (within the EMBA). Recent and historical surveys have identified this AMP as comprising mainly a flat bottom topography with variable benthic filter feeder communities. In a 2017 survey, filter feeder communities were dominated by hydroids, sea pens and crinoids, with low numbers of sponges, whips and gorgonians (Keesing 2019). A total of 76 sponge species were identified within the Montebello AMP during the 2017 survey, with most of these species occurring within shallow areas of the AMP (Keesing 2019).

Within the wider EMBA, the NWMR has been identified as a sponge diversity hotspot with a high variety of areas of potentially high and unique sponge biodiversity, particularly in the Commonwealth Waters of Ningaloo Marine Park (CALM 2005, Rees et al. 2004).

Other Benthic Communities

Woodside has collected numerous biological grab samples of the unconsolidated seabed sediments at the NRC and the surrounding area, as well as additional sampling throughout the broader region (Heyward et al. 2001, SKM 2007a). Studies have revealed that infauna associated with soft unconsolidated sediment habitat in the area of the NWS Province is widespread and well represented along the continental shelf and upper slopes (Brewer et al. 2007, LeProvost Dames & Moore 2000, Rainer 1991, RPS 2012, SKM 2007a, Woodside Energy 2005).

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4.5.2 Species

4.5.2.1 Protected Species

The EPBC Act PMST has been used to identify listed species that may occur within and adjacent to the Operational Area and the wider EMBA; this informs the assessment of planned events as well as unplanned events in Sections 6.6, 6.7, and 6.8. EPBC Act PMST reports were generated to identify MNES within the Operational Area and the EMBA for the worst-case loss of well containment scenario (this encompasses the different hydrocarbon fates for all credible hydrocarbon spill scenarios). Note: The EPBC Act PMST is a general database that conservatively identifies areas in which protected species have the potential to occur.

A total of 61 EPBC Act listed species (28 threatened species and 53 migratory species) considered to be MNES were identified as potentially occurring within the wider EMBA, of which a subset of 32 species were identified as potentially occurring within the Operational Area (Table 4-3). The full list of marine species identified from the PMST is provided in Appendix C. Note: Several MNES that are not considered to be credibly impacted (e.g. terrestrial species within the wider EMBA) were identified by the EPBC Act PMST reports, and were excluded from further consideration (see Appendix C for the list of these species and their justification for exclusion). One additional fish species (southern bluefin tuna) and one additional shark species (scalloped hammerhead), which are Conservation Dependent under the EPBC Act but are not currently included in the EPBC Act PMST, were found within the EMBA. These species are described in Section 4.5.2.7.

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Table 4-2: Species identified by the EPBC Act Protected Matters search as potentially occurring within or using habitat in the Operational Area and/or EMBA

Species Name	Common Name	Threatened Status	Migratory Status	Operational Area	EMBA
Mammals					
Balaenoptera borealis	Sei Whale	Vulnerable	Migratory	Yes (Y)	Y
Balaenoptera musculus	Blue Whale	Endangered	Migratory	Y	Y
Balaenoptera physalus	Fin Whale	Vulnerable	Migratory	Y	Y
Megaptera novaeangliae	Humpback Whale	Vulnerable	Migratory	Y	Y
Balaenoptera edeni	Bryde's Whale	Not applicable (N/A)	Migratory	Y	Y
Orcinus orca	Killer Whale	N/A	Migratory	Y	Y
Physeter macrocephalus	Sperm Whale	N/A	Migratory	Y	Y
Tursiops aduncus	Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	N/A	Migratory	Y	Y
Sousa chinensis	Indo-Pacific Humpback Dolphin	N/A	Migratory	N/A	Y
Eubalaena australis	Southern Right Whale	Endangered	Migratory	N/A	Y
Balaenoptera bonaerensis	Antarctic Minke Whale	N/A	Migratory	N/A	Y
Dugong dugon	Dugong	N/A	Migratory	N/A	Y
Reptiles					
Caretta caretta	Loggerhead Turtle	Endangered	Migratory	Y	Y
Chelonia mydas	Green Turtle	Vulnerable	Migratory	Y	Y
Dermochelys coriacea	Leatherback Turtle	Endangered	Migratory	Y	Y
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable	Migratory	Y	Y
Natator depressus	Flatback Turtle	Vulnerable	Migratory	Y	Y
Aipysurus apraefrontalis	Short-nosed Sea snake	Critically Endangered	N/A	N/A	Y
Fishes and Elasmobranchs					
Carcharias taurus	Grey Nurse Shark (west coast population)	Vulnerable	N/A	Y	Y
Carcharodon carcharias	Great White Shark	Vulnerable	Migratory	Y	Y

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Species Name	Common Name	Threatened Status	Migratory Status	Operational Area	EMBA
Pristis zijsron	Green Sawfish	Vulnerable	Migratory	Y	Y
Rhincodon typus	Whale Shark	Vulnerable	Migratory	Y	Y
Anoxypristis cuspidata	Narrow Sawfish	N/A	Migratory	Y	Y
Isurus oxyrinchus	Shortfin Mako	N/A	Migratory	Y	Y
Isurus paucus	Longfin Mako	N/A	Migratory	Y	Y
Manta alfredi	Reef Manta Ray	N/A	Migratory	Y	Y
Manta birostris	Giant Manta Ray	N/A	Migratory	Y	Y
Pristis clavata	Dwarf Sawfish	Vulnerable	Migratory	N/A	Y
Lamna nasus	Porbeagle, Mackerel Shark	N/A	Migratory	N/A	Y
Birds					
Calidris canutus	Red Knot, Knot	Endangered	Migratory	Y	Y
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Critically Endangered	Migratory	Y	Y
Anous stolidus	Common Noddy	N/A	Migratory	Y	Y
Calonectris leucomelas	Streaked Shearwater	N/A	Migratory	Y	Y
Fregata ariel	Lesser Frigatebird	N/A	Migratory	Y	Y
Fregata minor	Great Frigatebird	N/A	Migratory	Y	Y
Actitis hypoleucos	Common Sandpiper	N/A	Migratory	Y	Y
Calidris acuminata	Sharp-tailed Sandpiper	N/A	Migratory	Y	Y
Calidris melanotos	Pectoral Sandpiper	N/A	Migratory	Y	Y
Pandion haliaetus	Osprey	N/A	Migratory	Y	Y
Calidris ferruginea	Curlew Sandpiper	Critically Endangered	Migratory	N/A	Y
Limosa lapponica baueri	Bar-tailed Godwit	Vulnerable	Migratory	N/A	Y
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit	Critically Endangered	N/A[1]	N/A	Y
Macronectes giganteus	Southern Giant-Petrel	Endangered	Migratory	N/A	Y

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Species Name	Common Name	Threatened Status	Migratory Status	Operational Area	EMBA
Malurus leucopterus edouardi	White-winged Fairy-wren	Vulnerable	N/A	N/A	Y
Papasula abbotti	Abbott's Booby	Endangered	N/A	N/A	Y
Pterodroma mollis	Soft-plumaged Petrel	Vulnerable	N/A	N/A	Y
Sternula nereis nereis	Australian Fairy Tern	Vulnerable	N/A	N/A	Y
Thalassarche impavida	Campbell Albatross	Vulnerable	Migratory	N/A	Y
Rostratula australis	Australian Painted-snipe	Endangered	N/A	N/A	Y
Apus pacificus	Fork-tailed Swift	N/A	Migratory	N/A	Y
Ardenna carneipes	Flesh-footed Shearwater	N/A	Migratory	N/A	Y
Ardenna pacifica	Wedge-tailed Shearwater	N/A	Migratory	N/A	Y
Hydroprogne caspia	Caspian Tern	N/A	Migratory	N/A	Y
Onychoprion anaethetus	Bridled Tern	N/A	Migratory	N/A	Y
Phaethon lepturus	White-tailed Tropicbird	N/A	Migratory	N/A	Y
Sterna dougallii	Roseate Tern	N/A	Migratory	N/A	Y
Sternula albifrons	Little Tern	N/A	Migratory	N/A	Y
Charadrius veredus	Oriental Plover	N/A	Migratory	N/A	Y
Glareola maldivarum	Oriental Pratincole	N/A	Migratory	N/A	Y
Thalasseus bergii	Crested Tern	N/A	Migratory	N/A	Y
Tringa nebularia	Common Greenshank	N/A	Migratory	N/A	Y

** Listed as migratory at the species level*

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4.5.2.2 Listed Threatened Species Recovery Plans

The requirements of the species recovery plans and conservation advices (Table 4-3) were considered to identify any aspects that may be applicable to the risk assessment (Section 5). Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to conserve a listed species or ecological community.

Table 4-3 outlines the recovery plans and conservation advice relevant to those species identified as potentially occurring within or using habitat in the Operational Area and EMBA by the EPBC Act PMST (Appendix C), and summarises the key threats to those species, as described in relevant recovery plans and conservation advices.

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Table 4-3: Conservation advice for EPBC Act listed species considered during environmental risk assessment

Species	Recovery plan/conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions	Relevant EP Section
All Vertebrate Fauna				
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on vertebrate marine life (DoEE 2018)	Marine debris	No explicit management actions for non–fisheries-related industries (note that management actions in the plan relate largely to management of fishing waste (e.g. ‘ghost’ gear), and State and Commonwealth management through regulation)	6.7.2
Marine Mammals				
Sei whale	Conservation advice *Balaenoptera borealis* sei whale (Threatened Species Scientific Committee 2015a)	Noise interference	Assess and manage acoustic disturbance	6.6.3
		Vessel disturbance	Assess and manage physical disturbance and development activities	6.7.3
Blue whale	Conservation management plan for the blue whale: A recovery plan under the EPBC Act 1999 2015–2025 (Commonwealth of Australia 2015)	Noise interference	Assess and address anthropogenic noise	6.6.3
		Vessel disturbance	Minimise vessel collisions	6.7.3
Fin whale	Approved conservation advice for *Balaenoptera physalus* (fin whale) (Threatened Species Scientific Committee 2015b)	Noise interference	Assess and address anthropogenic noise	6.6.3
		Vessel disturbance	Minimise vessel collisions	6.7.3
Humpback whale	Approved conservation advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee 2015c)	Noise interference	For actions involving acoustic impacts (e.g. pile driving, explosives) on humpback whale calving, resting, feeding area, or confined migratory pathways, site-specific acoustic modelling should be undertaken (including cumulative noise impacts)	6.6.3
		Vessel disturbance	Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required, implement appropriate mitigation measures to reduce the risk of vessel strike	6.7.3
		Noise interference	Assess and address anthropogenic noise	6.6.3

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Species	Recovery plan/conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions	Relevant EP Section
Southern right whale	Conservation management plan for the southern right whale: a recovery plan under the EPBC Act 1999 2011–2021 (DSEWPaC 2012b)	Vessel disturbance	Minimise vessel collisions	6.7.3
Reptiles				
All marine turtle species (loggerhead, green, leatherback, hawksbill, flatback)	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Chemical and terrestrial discharge (oil pollution)	Ensure spill risk strategies and response programs include management for marine turtles and their habitats	Appendix D
		Light pollution	Minimise light pollution	6.8.3 to 6.8.9
		Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat	6.7.3
		Noise interference	No explicit relevant management actions; vessel strikes identified as a threat	6.6.3
Leatherback turtle	Approved conservation advice on *Dermochelys coriacea* (Threatened Species Scientific Committee 2008a)	Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat	6.7.3
Short-nosed sea snake	Approved conservation advice for *Aipysurus apraefrontalis* (short-nosed sea snake) (Department of the Environment 2013a)	No additional threats identified (excl. marine debris)	None applicable	N/A
Sharks and Rays				
Grey nurse shark (west coast population)	Recovery plan for the grey nurse shark (*Carcharias taurus*) (Department of the Environment 2014)	No additional threats identified (excl. marine debris)	None applicable	N/A
White shark	Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC 2013b)	No additional threats identified (excl. marine debris)	None applicable	N/A
All sawfish (green, dwarf, freshwater)	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia 2015b)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat	6.8.3 to 6.8.9

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Species	Recovery plan/conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions	Relevant EP Section
Green sawfish	Approved conservation advice for green sawfish (Threatened Species Scientific Committee 2008b)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat	6.8.3 to 6.8.9
Dwarf sawfish	Approved conservation advice for *Pristis clavata* (dwarf sawfish) (Threatened Species Scientific Committee 2009)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat	6.8.3 to 6.8.9
Whale shark	Approved Conservation Advice for *Rhincodon typus* (whale shark) (Threatened Species Scientific Committee 2015d)	Vessel disturbance	Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations, and along the northward migration route that follows the northern WA coastline along the 200 m isobaths	6.7.3
	Whale shark (*Rhincodon typus*) recovery plan 2005–2010[4] (Department of the Environment and Heritage [DEH] 2005a)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as a threat	6.8.3 to 6.8.9
Birds				
Migratory shorebird species	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia 2015c)	Habitat degradation/ modification	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes	6.8.3 to 6.8.9
Curlew sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (Threatened Species Scientific Committee 2015f)	Habitat loss and degradation from pollution	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment process	6.8.3 to 6.8.9
Red knot	Approved Conservation Advice for *Calidris canutus* (Red knot) (Threatened Species Scientific Committee 2016a)	Pollution/contamination	No explicit relevant management actions; pollution identified as a threat	6.8.3 to 6.8.9
Bar-tailed godwit (baueri)	Conservation advice *Limosa lapponica baueri* bar-tailed godwit (western Alaskan) (Threatened Species Scientific Committee 2016d)	Habitat degradation/ modification	No explicit relevant management actions; habitat degradation/modification identified as a threat	6.8.3 to 6.8.9

[4] The Whale shark (*Rhincodon typus*) recovery plan ceased to be in effect on 1 October 2015; however, the conservation advice in this plan was considered to inform the context of the environmental risk assessment for the Petroleum Activities Program.

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Species	Recovery plan/conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant Conservation Actions	Relevant EP Section
Albatrosses and giant petrels (southern giant-petrel)	National recovery plan for threatened albatrosses and giant petrels (DSEWPaC 2011)	Marine pollution	No explicit relevant management actions; pollution identified as a threat	6.8.3 to 6.8.9
Northern Siberian bar-tailed godwit	Conservation advice *Limosa lapponica menzbieri* bar-tailed godwit (northern Siberian) (Threatened Species Scientific Committee 2016e)	Habitat degradation/ modification	No explicit relevant management actions; habitat degradation/modification identified as a threat	6.8.3 to 6.8.9
Eastern curlew	Approved Conservation Advice for *Numenius madagascariensis* (Eastern Curlew) (Threatened Species Scientific Committee 2015g)	Habitat loss and degradation from pollution	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment process	6.8.3 to 6.8.9
Abbott's booby	Conservation advice *Papasula abbotti* Abbott's booby (Threatened Species Scientific Committee 2015h)	No additional threats identified (ex. marine debris)	None applicable	N/A
Soft-plumaged petrel	Conservation advice *Pterodroma mollis* soft-plumage petrel (Threatened Species Scientific Committee 2015i)	Habitat degradation/ modification	No explicit relevant management actions; habitat degradation/modification identified as a threat	N/A
Australian fairy tern	Conservation advice for *Sterna nereis* (Fairy tern) (Threatened Species Scientific Committee 2011)	Habitat degradation/ modification	No explicit relevant management actions; habitat degradation/modification identified as a threat	6.8.3 to 6.8.9
White-winged fairy-wren	Conservation advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren (Barrow Island)) (Threatened Species Scientific Committee 2008)	Habitat degradation/ modification	No explicit relevant management actions; habitat degradation/modification identified as a threat	6.8.3 to 6.8.9

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4.5.2.3 Biologically Important Areas

A review of the DoEE National Conservation Values Atlas identified that these BIAs overlap spatially with the Operational Area:

- foraging area for the wedge-tailed shearwater during its breeding season (August–April)
- foraging area for whale sharks northward from Ningaloo Reef along the 200 m isobath, with seasonally high use (April to June)
- internesting BIA for flatback turtles around the Montebello Islands (Hermite Islands, Northwest Island and Trimouille Island) (nesting between December to March).

Several BIAs occur within the wider EMBA, as listed in Table 4-4. Additional information on BIAs is provided in the species-specific summaries in Section 4.5.2.

Table 4-4: BIAs overlapping the Operational Area and within the wider EMBA

Species	BIA Type (location)	Distance from Operational Area (km)
Marine Mammals		
Pygmy blue whale	Migration (Augusta to Derby along the shelf edge)	38
	Foraging (Ningaloo)	308
Dugong	Calving (Ningaloo)	261
	Breeding (Ningaloo)	261
	Nursing (Ningaloo)	261
	Foraging (Ningaloo)	261
Humpback whale	Migration (north and south)	29
	Resting (Exmouth Gulf)	272
Marine Reptiles		
Loggerhead turtle	Internesting (Cohen Island[1] and Rosemary Island in the Dampier Archipelago, Montebello Islands)	71
	Nesting[2] (Cohen Island[1], Exmouth Gulf and Ningaloo coast)	93
Green turtle	Internesting (Dampier Archipelago[1], Montebello Islands, Barrow Island)	75
	Nesting[2] (Dampier Archipelago[1], Montebello Islands, Barrow Island, Muiron Islands, and North West Cape/Exmouth Gulf and Ningaloo coast)	75
	Foraging (Montebello Islands[1], Barrow Island)	51
	Mating (Montebello Islands[1], Barrow Island)	51
	Aggregation (Montebello Islands)	51
	Basking (Barrow Island)	110
Hawksbill turtle	Internesting (Dampier Archipelago[1], Montebello Islands, Lowendal Islands, Barrow Island, Thevenard Island, Ningaloo coast and Jurabi coast)	73
	Nesting[2] (Dampier Archipelago[1], Montebello Islands, Lowendal Islands, Thevenard Island, Barrow Island, Thevenard Island, Ningaloo coast and Jurabi coast)	73
	Mating (Montebello Islands[1], Lowendal Islands, Barrow Island)	75
	Foraging (Lowendal Islands[1], Barrow Island)	75

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Species	BIA Type (location)	Distance from Operational Area (km)
Flatback turtle	Internesting (Montebello Islands[1], Dampier Archipelago, Barrow Island, Thevenard Island, Ningaloo coast and Jurabi coast)	Overlapping[3]
	Nesting[2] (Dampier Archipelago[1], Montebello Islands, Barrow Island, Thevenard Island – south coast)	32
	Foraging (Montebello Islands[1], Barrow Island)	75
	Mating (Montebello Islands[1], Barrow Island)	75
	Aggregation (Montebello Islands)	75
Sharks, Fish and Rays		
Whale shark	Foraging (northward from Ningaloo along 200 m isobath)	Overlapping
	Foraging (Ningaloo Marine Park)	301
Birds		
Australian Fairy tern	Breeding (Pilbara and Gascoyne coast and islands[1])	70
Roseate tern	Breeding (Pilbara and Gascoyne coast and islands[1])	68
Wedge-tailed shearwater	Breeding (Pilbara and Gascoyne coast and islands[1])	Overlapping
Lesser crested tern	Breeding (Pilbara and Gascoyne coast and islands[1])	76
Lesser frigatebird	Breeding (Pilbara and Gascoyne coast and islands)	167
White-tailed tropicbird	Breeding (Rowley Shoals)	219
Little tern	Breeding (Rowley Shoals)	363

[1] Denotes the closest BIA to the Operational Area where multiple BIAs of the same type overlap the EMBA. Where relevant, distances have been provided for the BIAs closest to the Operational Area only.

[2] Identified as habitat critical to the survival of the species in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia, 2017). Note: These defined areas include internesting habitat, and therefore the distances to actual nesting beaches will be greater.

[3] BIA overlaps the Goodwyn-6 suspended exploration well section of the Operational Area only and is ~18 km from the Okha FPSO.

[4] Species is not listed as threatened or migratory under the EPBC Act (i.e. listed as least concern).

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4.5.2.4 Seasonal Sensitivities of Protected Species

Periods of the year coinciding with key environmental sensitivities for the Operational Area and the wider regional context, including EPBC Act listed threatened and/or migratory species, are presented in Table 4-5. These relate to breeding, foraging or migration of the indicated fauna.

Table 4-5: Key environmental sensitivities and indicative timings for migratory fauna identified within the Operational Area and/or wider EMBA

Species	January	February	March	April	May	June	July	August	September	October	November	December
Humpback whale – northern migration (Jurien Bay to Montebello)[1]												
Humpback whale – southern migration (Jurien Bay to Montebello)[2]												
Blue whale – northern migration (Exmouth, Montebello, Scott reef)[2]												
Blue whale – southern migration (Exmouth, Montebello, Scott Reef)[2]												
Sperm whale[5]												
Green turtle[6]												
Flatback turtle[7]												
Loggerhead turtle[8]												
Hawksbill turtle[9]												
Whale shark* – foraging/aggregation near Ningaloo[10]												
Manta ray – presence/aggregation/breeding Ningaloo[11]												
Australian fairy tern – breeding Ningaloo[10]												
Caspian tern – breeding Ningaloo[10]												
Crested tern – breeding Ningaloo[10]												
Osprey – breeding Ningaloo[10]												
Roseate tern – breeding Ningaloo[10]												
Wedge-tailed shearwater – various breeding sites within EMBA[12]												
Migratory shorebirds[13]												

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Species		January	February	March	April	May	June	July	August	September	October	November	December
	Species likely to be present in the region												
	Peak period. Presence of animals reliable and predictable each year												

References for species seasonal sensitivities:

1. *Environment Australia 2002, Jenner et al. 2001*
2. *DSEWPaC 2012a, McCauley and Jenner 2010*
3. *McCauley 2011*
4. *Department of Environmental Protection 2001*
5. *National Marine Fisheries Services 2006, Whitehead 2002a*
6. *Commonwealth of Australia 2017, CALM 2005, DSEWPaC 2012a*
7. *Commonwealth of Australia 2017, DSEWPaC 2012a*
8. *Commonwealth of Australia 2017, CALM 2005*
9. *Commonwealth of Australia 2017*
10. *CALM 2005, Environment Australia 2002*
11. *Environment Australia 2002*
12. *DSEWPaC 2012c, Environment Australia 2002*
13. *Bamford et al. 2008*

*(*Periods of sensitivity include whale shark foraging off Ningaloo Coast and foraging northward from the Ningaloo Marine Park along the 200 m isobath.)*

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4.5.2.5 Marine Mammals

Cetaceans – Whales

Sei Whale

Sei whales were identified as potentially occurring within the Operational Area and wider EMBA. Sei whales have a worldwide oceanic distribution and are expected to migrate seasonally between low-latitude wintering areas and high-latitude summer feeding grounds (Bannister et al. 1996, Prieto et al. 2012). Sei whales have been infrequently recorded in Australian waters (Bannister et al. 1996); however, these recordings may be incorrect as sei whales and Bryde's whales have a similar appearance. There are no known mating or calving areas in Australian waters (DoEE 2017). Although sei whales have been sighted inshore (near the Bonney Upwelling in Victoria), they prefer deep waters and typically occur in oceanic basins and continental slopes (Prieto et al. 2012). Neither the Operational Area nor wider EMBA are considered critical habitat for sei whales. Sei whales are likely to occur within the Operational Area, but their presence is likely to be rare and limited to a few individuals infrequently transiting the area.

Bryde's Whale

The Bryde's whale was identified as potentially occurring within the Operational Area and wider EMBA. The Bryde's whale occurs in tropical and temperate waters (Bannister et al. 1996, DoEE 2015). Bryde's whales occur in both oceanic and inshore waters, with the only key localities recognised in WA being the Abrolhos Islands (outside the EMBA) and north of Shark Bay (Bannister et al. 1996). Two forms are recognised: inshore (largely sedentary) and offshore (may undertake migration). Data suggests offshore whales may migrate seasonally, heading towards warmer tropical waters during the winter; however, information on migration is not well known (McCauley and Duncan 2011). There is some taxonomic confusion, with Bryde's whales bearing similarity to, and historically confused with, the sei whale (Bannister et al. 1996a), particularly in whaling catch statistics (Slijper et al. 1964).

Bryde's whales may occur through a broad area of the continental shelf in the NWMR, including the Operational Area and wider EMBA (McCauley and Duncan 2011, RPS Environment and Planning 2012). This species has been detected within the NWS Province from mid-December to mid-June, peaking in late February to mid-April (RPS Environment and Planning 2012). As such, the species may be seasonally encountered within the Operational Area, and is expected to occur in the wider EMBA, particularly in oceanic and continental slope waters.

Blue Whale

Blue whales were identified as potentially occurring within the Operational Area and wider EMBA. There are two recognised subspecies of blue whale in the Southern Hemisphere, both of which are recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus*) and the 'pygmy' blue whale (*Balaenoptera musculus brevicauda*) (Commonwealth of Australia 2015). In general, southern blue whales occur in waters south of 60° S and pygmy blue whales occur in waters north of 55° S (i.e. not in the Antarctic) (DEH 2005b). On this basis, nearly all blue whales sighted in the NWMR are likely to be pygmy blue whales.

Pygmy blue whales are known to migrate seasonally between temperate/sub-Antarctic and tropical waters (Double et al. 2014). In the NWMR, pygmy blue whales migrate along the 500 m to 1000 m depth contour on the edge of the slope (i.e. west of the Operational Area). They are likely to feed opportunistically on ephemeral krill aggregations (DEWHA 2008). Sea noise loggers and satellite tracking at various locations along the WA coast have detected an annual northbound migration past Exmouth and the Montebello Islands between April and August, and southbound migration from October to the end of January, peaking in late November to early December (Double et al. 2014, McCauley and Duncan 2011, McCauley and Jenner 2010).

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Satellite tagging (2009–2012) of pygmy blue whales off the Perth Canyon confirmed the general distribution of pygmy blue whales was offshore in water depths >200 m and commonly >1000 m (Double et al. 2012b) (Figure 4-8). These data showed that whales tagged during March and April migrated northwards after tag deployment. The tagged whales travelled relatively near to the Australian coastline (100.0 ± 1.7 km) until reaching North West Cape, after which they travelled offshore (238.0 ± 13.9 km). Whales reached the northern terminus of their migration and potential breeding grounds in Indonesian waters by June (Double et al. 2014).

The 2015 Conservation Management Plan for the Blue Whale (Commonwealth of Australia 2015) has delineated the distribution area of blue whales in Australian waters and identified a number of BIAs for blue whales in the waters off WA (migratory corridor and foraging areas). The plan also documents that the pygmy blue whales that feed off the Perth Canyon in WA and those that feed within the Bonney Upwelling in South Australia (SA) and Victoria are from the same population. The migration BIA off the WA coast is ~38 km north of the Operational Area at the closest point and within the wider EMBA. Based on pygmy blue whale migration timing, the species may occur in the wider EMBA between April and August (northbound migration) and October to January (southbound migration). A possible foraging BIA is off the Ningaloo Coast (~308 km south-west of the Operational Area at the closest point, but within the wider EMBA), within which pygmy blue whales may feed (Double et al. 2014).

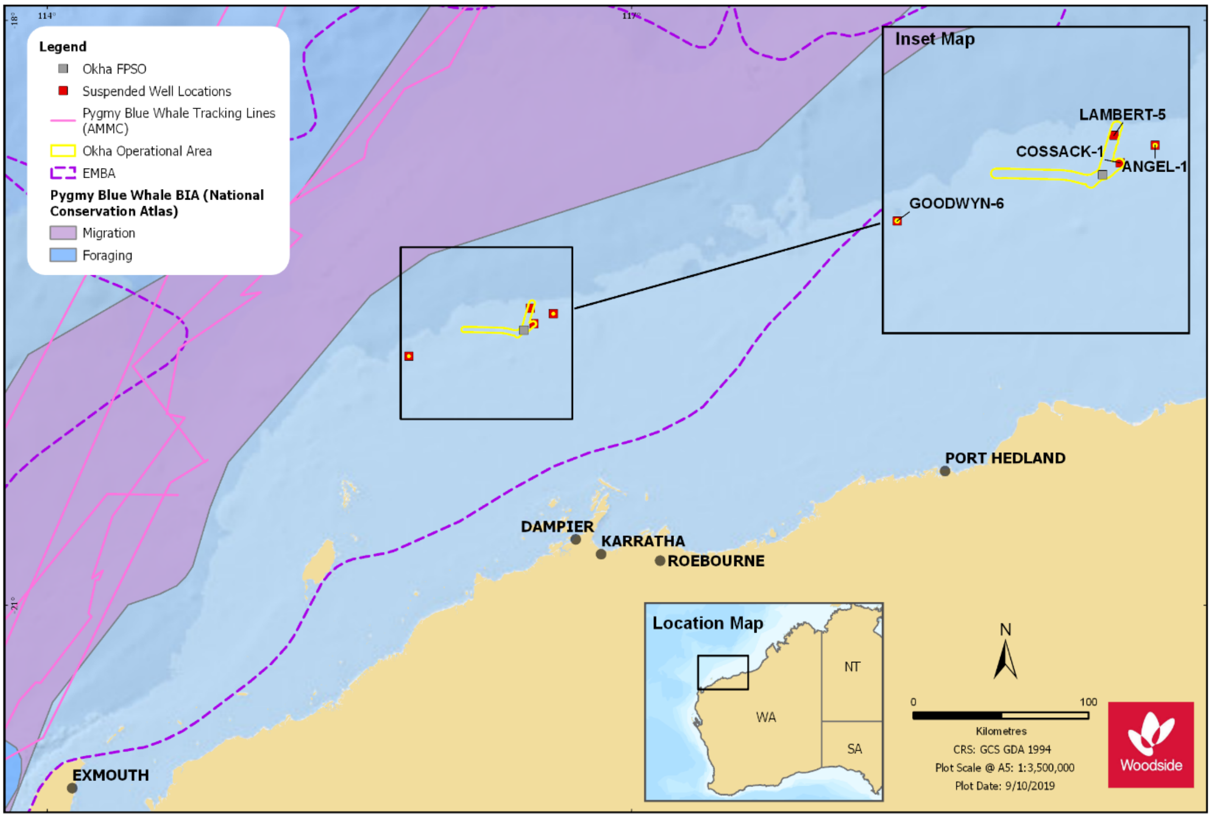

Figure 4-8: Pygmy blue whale satellite tracks and BIAs

Source: Double et al. 2012b, 2014

Fin Whale

Fin whales were identified as potentially occurring within the Operational Area and wider EMBA. The fin whale is the second largest species after the blue whale. Like other baleen whales, fin whales migrate annually between high-latitude summer feeding grounds and lower-latitude over-wintering areas (Bannister et al. 1996).

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Fin whales are thought to follow oceanic migration paths and are rarely encountered in coastal or continental shelf waters. The Australian Antarctic waters are important feeding grounds for fin whales but there are no known mating or calving areas in Australian waters (Morrice et al. 2004). There are also no known BIAs for fin whales in the NWMR. As such, the species may be encountered within the Operational Area, and is expected to occur in the wider EMBA, particularly in oceanic and continental slope waters.

Humpback Whale

Humpback whales were identified as occurring within the Operational Area and wider EMBA. The species regularly migrates seasonally between feeding grounds in the Southern Ocean and breeding and calving grounds off northern WA, particularly Camden Sound (Jenner et al. 2001). Calving typically occurs at the northern extent of the migration corridor (beyond the wider EMBA).

Woodside has conducted marine megafauna aerial surveys that have confirmed the temporal distribution of migrating humpback whales off North West Cape has remained consistent since baseline surveys were first conducted in 2000–2001 (RPS Environment and Planning 2010a). Most whales occurred in depths <500 m, with the greatest density of whales concentrated in water depths of 200–300 m. Only small numbers of whales were observed to occur in the deeper offshore waters. These survey results are consistent with satellite tagging studies (Double et al. 2010, 2012a) (Figure 4-9).

From North West Cape, northbound humpback whales travel along the edge of the continental shelf passing west of the Muiron, Barrow and Montebello Islands (Figure 4-9), peaking in late July (Jenner et al. 2001). The southern migratory route follows a relatively narrow track between the Dampier Archipelago and Montebello Islands. The humpback migration BIA is ~29 km from the Operational Area. Exmouth Gulf and Shark Bay are known resting/aggregation areas for southbound humpback whales. In particular, Exmouth Gulf is where cow/calf pairs may stay for up to two weeks during September (Jenner et al. 2001). The Exmouth Gulf humpback whale BIA overlaps the EMBA.

Noise loggers deployed near Woodside's GWA facility detected humpback whales present at the end of September, likely migrating south, and from June to mid-August in deeper water, nearer to the continental shelf, likely migrating north (RPS Environment and Planning 2012). The southward migration of cow/calf pairs is slightly later during October (and extending into November and December). During the southbound migration, it is likely that most individuals, particularly cow/calf pairs, stay closer to the coast than when they are on the northern migratory path. During these migration periods, humpback whales are not likely to overlap the Operational Area.

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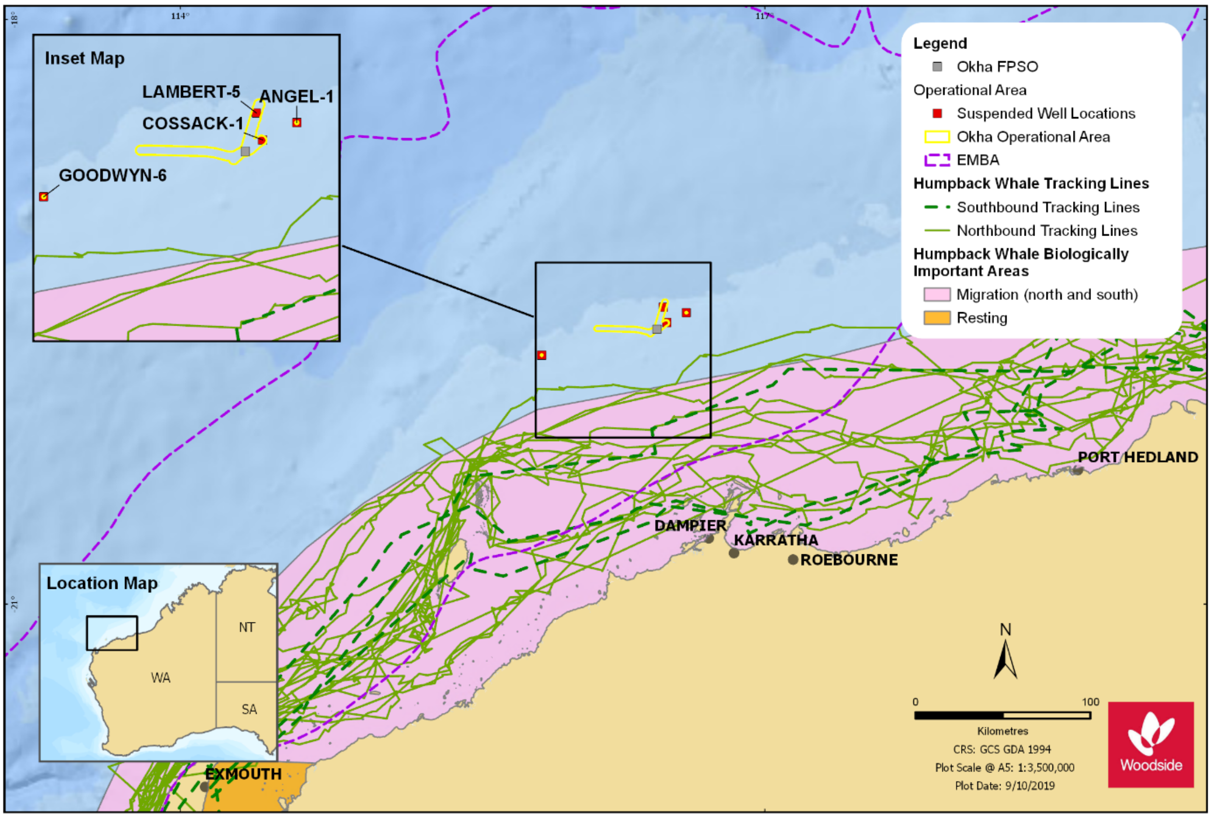

Figure 4-9: Humpback whale satellite tracks and BIA

Source: Double et al. 2010, 2012a

Sperm Whale

The sperm whale was identified as potentially occurring in the Operational Area and wider EMBA. Sperm whales are the largest of the toothed whales and are distributed worldwide in deep waters (>200 m) off continental shelves and sometimes near shelf edges (Bannister et al. 1996). The sperm whale is listed as a Migratory species under the EPBC Act. Sperm whales have been recorded in all Australian state waters and are known to migrate northward in winter and southwards in summer (Bannister et al. 1996). In WA, sperm whales have two BIAs recognised for foraging activities—west of Rottnest Island and along the southern coastline between Cape Leeuwin and Esperance. In deep water off the North West Cape, sperm whales have been sighted in pod sizes up to six animals between February and April from two separate surveys, in 2010 and 2017 (EPI Group 2017, RPS Environment and Planning 2010b).

Given the wide distribution of sperm whales and their preference for deeper oceanic waters, the Operational Area and wider EMBA is unlikely to represent an important habitat for this species. Their presence is likely to be rare and limited to a few individuals infrequently transiting the area.

Antarctic Minke Whale

Antarctic minke whales were identified as potentially occurring within the Operational Area and the wider EMBA. The Antarctic minke whale is distributed worldwide and has been recorded off all Australian states, feeding in cold waters and migrating to warmer waters to breed. The Antarctic minke whale is thought to migrate up the WA coast to ~20 °S to feed and possibly breed (Bannister et al. 1996); however, detailed information on the timing and location of migrations and breeding grounds is not well known. In the wider EMBA, the Antarctic minke whale may be seasonally present in low numbers during winter months. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the Operational Area.

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Southern Right Whale

Southern right whales were identified as potentially occurring within the wider EMBA. The southern right whale occurs primarily in waters between ~20 and 60 °S and moves from high-latitude feeding grounds in summer to warmer, low-latitude, coastal locations in winter (Bannister et al. 1996). Southern right whales aggregate in calving areas along the south coast of WA, such as Doubtful Island Bay, east of Israelite Bay and to a lesser extent Twilight Cove (DSEWPaC 2012b). During the calving season, between May and November, female southern right whales that are either pregnant or with calf can be present in shallow protected waters along the entire southern WA coast and west up to approximately Two Rocks, north of Perth. 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 whales are unlikely to occur in the EMBA.

Cetaceans – Dolphins and Porpoises

Killer Whale

Killer whales were identified as potentially occurring within the Operational Area and wider EMBA. Killer whales are found in all of the world's oceans, from the Arctic and Antarctic regions to tropical seas and have been recorded off all states of Australia (Bannister et al. 1996, DoE 2013, Ford et al. 2005). Killer whales appear to be more common in cold, deep waters; however, they have been observed along the continental slope and shelf (Bannister et al. 1996), as well as in shallow coastal areas of WA (RPS Environment and Planning 2010a).

There are no recognised key localities or important habitats for killer whales within the Operational Area or wider EMBA. Given the wide distribution of killer whales and their preference for colder waters, the Operational Area is unlikely to represent an important habitat for this species; their presence is likely to be rare and limited to a few individuals infrequently transiting the area. The species is expected to be present in the wider EMBA.

Spotted Bottlenose Dolphin (Arafura/Timor Sea Populations)

There are four known subpopulations of the spotted bottlenose dolphins, of which the Arafura/Timor Sea population was identified as potentially occurring within the Operational Area and wider EMBA. The spotted bottlenose dolphin is generally considered to be a warm water subspecies of the common bottlenose dolphin. Distribution is primarily inshore waters, often in depths <10 m (Bannister et al. 1996). They are known to occur from Shark Bay, north to the western edge of the Gulf of Carpentaria. Given the distribution of spotted bottlenose dolphins, and their preference for shallow coastal waters, the Operational Area is unlikely to constitute important habitat for this species.

Their presence is likely to be rare and limited to infrequent transiting of the Operational Area, although they are expected to occur in the wider EMBA.

Indo-Pacific Humpback Dolphin

The Indo-Pacific humpback dolphin may be present in the wider EMBA, particularly at the Montebello Islands (Raudino et al. 2018), although this species was not identified as occurring within the Operational Area. The Indo-Pacific humpback dolphin is now recognised as two distinct species—the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Australian humpback dolphin (*S. sahulensis*) (Jefferson and Rosenbaum 2014). Distribution of the Indo-Pacific humpback dolphin in Australia is tropical, occurring north of 29 °S and 24 °S off the east and west coasts of Australia respectively (Bannister et al. 1996). Humpback dolphins inhabit shallow coastal, estuarine habitats in tropical and subtropical regions, generally in depths <20 m (Corkeron et al. 1997, Jefferson 2000, Jefferson and Rosenbaum 2014). Given their preference for shallow coastal habitats, the species is not likely to occur within the Operational Area but will occur within the wider EMBA.

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Dugong

The dugong may be present in the wider EMBA, although was not identified as occurring within the Operational Area, which is offshore in deep water that does not support seagrass habitat and does not contain any critical dugong habitat. Dugongs are distributed along the WA coast throughout the Gascoyne, Pilbara and Kimberley, with notable populations in these areas (DSEWPaC 2012a, Marsh et al. 2002, Preen et al. 1997):

- Ningaloo Marine Park (State Waters) (~305 km south-west of the Operational Area)
- Exmouth Gulf (~272 km south-west of the Operational Area)
- Shark Bay (~610 km south of the Operational Area).

Dugong distribution is correlated with seagrass habitats in which dugong feed, although water temperature has also been correlated with dugong movements and distribution (Preen et al. 1997, Preen 2004). Dugongs are known to migrate hundreds of kilometres between seagrass habitats (Sheppard et al. 2006). Dugongs may occur along the Ningaloo Coast and around islands of the Pilbara Coast, within the wider EMBA.

The Operational Area does not encompass dugong BIAs; however, several do occur in the nearshore waters of Ningaloo Reef, within the wider EMBA (Table 4-4).

4.5.2.6 Marine Reptiles

Marine Turtles

Five of the six marine turtle species recorded for the NWMR have the potential to occur within the Operational Area (Appendix C)—the loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle and the flatback turtle.

With consideration of the distance offshore, depth range of surrounding offshore waters (80 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 beaches (such as within Dampier Archipelago and Montebello Islands) are >90 km from the Operational Area (note areas defined as nesting habitat critical to the survival of marine turtle species extend beyond nesting beaches, refer to Table 4-4 for a list of the minimum distances to these areas for each species).

Four of the turtle species (green, loggerhead, flatback and hawksbill) have significant nesting rookeries on beaches along the mainland coast and islands in the wider EMBA region including the Ningaloo Coast, and several significant nesting sites occur in the region beyond the wider EMBA, including the Muiron Islands and North West Cape (Commonwealth of Australia 2017, Limpus 2007, 2008a, 2008b, 2009). Table 4-6 has additional details of the marine turtle species identified, including breeding and nesting seasons, diet and key habitats within the NWMR (including areas outside the wider EMBA).

Table 4-6: Key information on marine turtles in the NWMR

Turtle Species	Key Seasons within the NWMR	Diet	Key Habitats
Green turtle	**Breeding**: Approximately September to December. **Nesting**: November to March. Peak period from January to March.	Seagrasses and algae	**Preferred habitat**: Nearshore reef habitats in the photic zone. **Distribution**: Ningaloo coast to Lacepede Islands. **Major nesting sites**: Montebello Islands, Barrow Island, Muiron Islands, some islands of the Dampier Archipelago, and North West Cape. **Internesting habitat**: Generally within 10 km of nesting beaches (Waayers et al. 2011).

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Turtle Species	Key Seasons within the NWMR	Diet	Key Habitats
			Nearest BIA/Critical Habitat: None overlap the Operational Area. Refer to Table 4-4 for BIAs/habitat critical to the survival of a species* within the wider EMBA.
Loggerhead turtle	**Breeding**: Approximately September to March. **Nesting**: November to March. Peak period from late December to early January.	Carnivorous, feeding mainly on molluscs and crustaceans	**Preferred habitat**: Nearshore and island coral reefs, bays and estuaries in tropical and warm temperate latitudes. **Distribution**: Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. **Major nesting sites**: Principally from Dirk Hartog Island, along the Gnaraloo and Ningaloo Coast to North West Cape and the Muiron Islands. There have been occasional records from Varanus and Rosemary Islands in the Pilbara. Late summer nesting recorded for Barrow Island, Lowendal Islands and Dampier Archipelago. **Internesting habitat**: Limited data on Australian loggerhead turtles; however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches (DSEWPaC 2012a). **Nearest BIA/Critical Habitat**: None overlap the Operational Area. Refer to Table 4-4 for BIAs/habitat critical to the survival of a species* within the wider EMBA.
Hawksbill turtle	**Breeding**: All year round. **Nesting**: All year round with peak in October to February.	Mainly sponges, also seagrasses, algae, soft corals and shellfish	**Preferred habitat**: Nearshore and offshore reef habitats. **Distribution**: Shark Bay north to Dampier Archipelago. **Major nesting sites**: The most significant rookery in WA is at Rosemary Island. Other rookeries include Varanus Island in the Lowendal group, some islands in the Montebello group and along the Ningaloo Coast (Limpus 2009). **Internesting habitat**: Limited data on Australian hawksbill turtles; however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches (DSEWPaC 2012a). **Nearest BIA/Critical Habitat**: None overlap the Operational Area. Refer to Table 4-4 for BIAs/ habitat critical to the survival of a species* within the wider EMBA.
Flatback turtle	**Breeding**: September to January. **Nesting**: November to March with peak period in December to March.	Carnivorous, feeding mainly on soft bodied prey such as sea cucumbers, soft corals and jellyfish	**Preferred habitat**: Nearshore and offshore subtidal and soft-bottomed habitats of offshore islands. **Distribution**: Pilbara genetic stock: Shark Bay north to Dampier Archipelago. **Major nesting sites**: The largest nesting sites of the Pilbara region are Barrow Island and the mainland coast (Mundabullangana Station near Cape Thouin and smaller nesting sites at Cemetery Beach in Port Hedland and Bell's Beach near Wickham). Other significant rookeries include Thevenard Island, the Montebello Islands, Varanus Island, the Lowendal Islands and islands of the Dampier Archipelago. **Internesting habitat**: Up to 70 km from nesting beaches (Waayers et al. 2011, Whittock et al. 2014). Satellite tracking of flatback turtle nesting populations at Barrow Island indicates that this species travels

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Turtle Species	Key Seasons within the NWMR	Diet	Key Habitats
			east of Barrow Island, towards WA mainland coastal waters, between nesting events. **Nearest BIA/Critical Habitat**: An internesting BIA around the Montebello Islands overlaps the suspended exploration well (Goodwyn-6) section of the Operational Area. The boundary of the BIA is ~18 km from the Okha FPSO. Refer to Table 4-4 for BIAs/habitat critical to the survival of a species* within the wider EMBA.
Leatherback turtle	No confirmed nesting activity in WA.	Carnivorous, feeding mainly in the open ocean on jellyfish and other soft-bodied invertebrates	**Preferred habitat**: Nearshore, coastal tropical and temperate waters may be encountered within the NWMR but there are no known nesting sites within the NWMR. **Nearest BIA/Critical Habitat**: No known BIAs for leatherback turtles in the Operational Area or wider EMBA.

** Habitat critical to the survival of a species identified in the Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017)*

Post-nesting migratory routes for green, hawksbill and flatback turtles have been recorded for the Pilbara area (Barrow Island and mainland sites) (Chevron Australia 2012). Green turtle tracking for post-nesting individuals from Scott Reef (Guinea 2011) indicates no overlap with the Operational Area. Green, flatback and hawksbill turtles travelling from nesting sites to foraging grounds generally move east or south of Barrow Island, around or through the Dampier Archipelago and along the coast towards foraging grounds to the north (north of Broome). The exception is hawksbill turtles, which travel south to the coastal island chain south of Barrow Island (Chevron Australia 2012). Tracking data indicate the turtles travel and forage in relatively shallow water, with hawksbill turtles in depths <10 m, green turtles <25 m and flatback turtles <70 m (Chevron Australia 2012).

Sea snakes

Sea snakes occur along the NWS Province and are reported to occur in offshore and nearshore waters. They occupy diverse habitats including coral reefs, turbid water habitats and deeper water (Guinea et al. 2004). Species exhibit habitat preferences depending on water depth, benthic habitat, turbidity and season (Heatwole and Cogger 1993). Most information on the occurrence of sea snakes has been sourced from bycatch logs maintained by the Northern Prawn Fishery (DEWHA 2008).

The short-nosed sea snake, listed as Critically Endangered under the EPBC Act, was identified as potentially occurring within the Operational Area. This species has primarily been recorded at Ashmore Reef and Cartier Island on the Sahul Shelf, which are >1000 km from the Operational Area and beyond the wider EMBA.

Sea snakes of the families Hydrophiidae and Laticaudidae are widespread in the wider EMBA and are protected under the EPBC Act. The PMST identified 16 species of sea snake listed as marine under the EPBC Act within the wider EMBA (Appendix C). The most commonly sighted sea snake in the region is the olive sea snake (*Aipysurus laevis*), which is generally found along lower reef edges and upper lagoon slopes of leeward reefs. The olive sea snake is associated with shallow water, as large, deepwater expanses create a significant barrier to movement. Given the water depth of the Operational Area, sea snake sightings will be infrequent and likely comprise few individuals.

4.5.2.7 Fishes and Elasmobranchs

Seahorses and Pipefish

The Protected Matters search identified 40 species of pipefish, pipehorses and seahorses listed as under the EPBC Act within the wider EMBA (Appendix C). Bycatch data (Department of Fisheries

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2010) indicates they are uncommon in deeper continental shelf waters (50–200 m), so are unlikely to occur within the Operational Area. Species within this family (Syngnathidae) are commonly found in seagrass and sandy habitats around coastal islands and shallow reef areas along the NWS Province, and are likely to be found in coastal areas including the Ningaloo Coast. Within the wider EMBA, pipefish, pipehorses and seahorses may be encountered in a wide variety of shallow habitats, including seagrass meadows, reefs and sandy substrates.

Sawfish

Narrow Sawfish

The narrow sawfish was identified as potentially occurring within the Operational Area. This species is widely distributed throughout the Indo-Pacific region, with records spanning from the Arabian Gulf to Japan. In Australia, the species may have a broad tropical distribution from approximately North West Cape in WA to southern Queensland. Like other sawfish species, the narrow sawfish has experienced considerable decline in numbers due to human activities, including fishing and habitat loss/damage (Cavanagh et al. 2003). Interactions between prawn trawl fishing in coastal waters has been identified as a threat for narrow sawfish in Australia (Commonwealth of Australia 2015b).

Like other sawfish in the family Pristidae, the narrow sawfish prefers shallow coastal, estuarine and riverine habitats, although may occur in waters up to 100 m deep (D'Anastasi et al. 2013). Given the water depth of the Operational Area (~80–125 m) and distance from preferred habitats, narrow sawfish are not expected to occur within the Operational Area. However, the species may be found within the broader EMBA in shallow coastal waters and estuaries.

Green Sawfish

The green sawfish was identified as potentially occurring within the Operational Area. The species was once widely distributed in coastal waters along the northern Indian Ocean, although it is believed northern Australia may be the last region where significant populations exist (Stevens et al. 2005). Within Australia, green sawfish are currently distributed from about the Whitsundays in Queensland across northern Australian waters to Shark Bay in WA (Commonwealth of Australia 2015b). Preferred habitat for green sawfish includes shallow coastal waters and tidal creeks (Chevron Australia 2014). Despite records of the species in deeper offshore waters, green sawfish typically occur in the inshore fringe with a strong association with mangroves and adjacent mudflat habitats (Commonwealth of Australia 2015b, Stevens et al. 2005). Movements within these preferred habitats correlate with tidal movements (Stevens et al. 2008).

The Multi-species Recovery Plan for Sawfish and River Sharks indicates 'known to occur' distribution includes offshore waters of the NWS, with 'known' pupping areas in coastal waters north of Port Hedland to Roebuck Bay and pupping 'likely to occur' south of Port Hedland, Exmouth Gulf and North West Cape (Commonwealth of Australia 2015b). The Operational Area is not considered a sensitive area for the green sawfish.

Given the water depth of the Operational Area (~80–125 m) and distance from preferred habitats, green sawfish are not expected to occur within the Operational Area. However, the species may be found within the broader EMBA, particularly mangroves and tidal creeks.

Dwarf Sawfish

The dwarf sawfish is found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (Kyne et al. 2013) and was identified as potentially occurring within the wider EMBA. Dwarf sawfish typically inhabit shallow (2–3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al. 2008). Juvenile dwarf sawfish use estuarine habitats in north-western WA as nursery areas (Thorburn et al. 2008, Threatened Species Scientific Committee 2009), and migrate to deeper waters as adults. Most capture locations for the species in WA waters have occurred within King

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Sound (beyond the wider EMBA) and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al. 2010). Individuals have also been recorded from Eighty Mile Beach, and occasional individuals have also been taken from considerably deeper water from trawl fishing (Morgan et al. 2010). The species may be present in coastal waters within the wider EMBA.

Sharks

Whale Shark

The whale shark was identified as potentially occurring within the Operational Area. Whale sharks aggregate annually to feed in the waters off the Ningaloo Coast 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. The population (comprising individuals that visit the reef at some point during their lifetime) has been estimated to range between 300 and 500 individuals; the number visiting Ningaloo Reef in any given year is expected to be somewhat smaller (Meekan et al. 2006). 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. At Ningaloo Reef, whale sharks stay within a few kilometres of the shore and in waters ~30–50 m deep (Wilson et al. 2006).

After the aggregation period, the distribution of the whale shark is largely unknown. Tagging, aerial and vessel surveys suggest the group disperses widely, up to 1800 km away. Satellite tracking has shown that the sharks may follow three migration routes from Ningaloo Reef (Meekan and Radford 2010, Wilson et al. 2006) (Figure 4-10):

- north-west, into the Indian Ocean
- directly north, towards Sumatra and Java (Indonesia)
- north-east, passing through the NWS Province travelling along the shelf break and continental slope.

These tagging studies provided the justification for a foraging BIA for whale sharks that overlaps the Operational Area, as shown in Figure 4-10. Though the BIA has been defined as a foraging area for whale sharks, it is more likely to be a migration pathway with whale sharks undertaking opportunistic foraging. Whale sharks may traverse through the Operational Area during their migrations to and from Ningaloo Reef. However, whale shark presence within the area is expected to be of a relatively short duration and not in significant numbers, given the main aggregations are recorded in coastal waters, particularly the Ningaloo Reef edge (CALM 2005).

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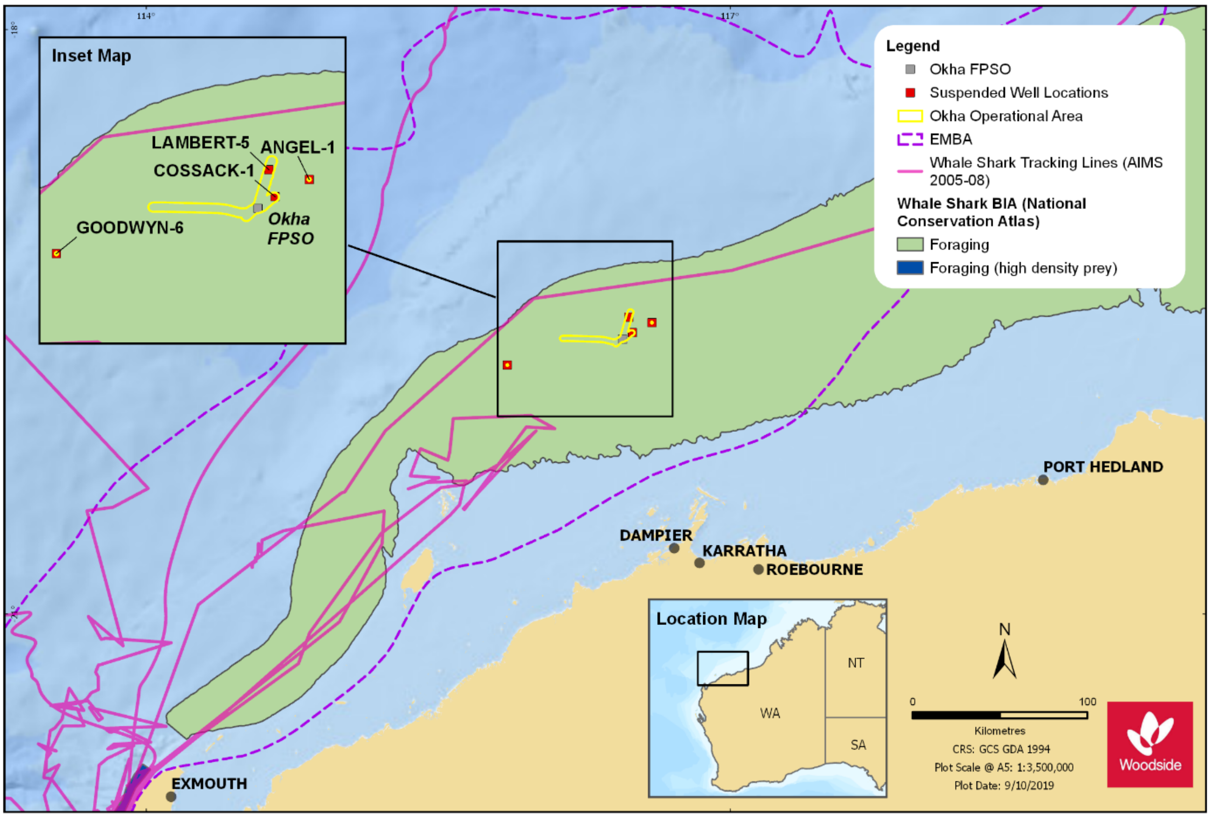

Figure 4-10: Satellite tracks of whale sharks tagged between 2005 and 2008

Source: Meekan and Radford (2010)

Porbeagle Shark

The porbeagle shark is found in temperate, sub-Arctic and sub-Antarctic waters worldwide, and was identified as potentially occurring within the wider EMBA. The species can thermo-regulate physiologically, allowing it to occupy cooler waters than other shark species. The porbeagle shark has a wide vertical range within the water column, with tagging studies recording the species between the surface and > 700 m water depth (Saunders et al. 2011). Given its preference for cooler waters (Bruce 2013), the porbeagle shark may occur in temperate waters in the wider EMBA.

Grey Nurse Shark

The grey nurse shark was identified as potentially occurring within the Operational Area. This species has a broad distribution in inner continental shelf waters, primarily in subtropical to cool temperate waters. Off WA, the grey nurse shark occurs primarily in south-west coastal waters between 20 m and 140 m depth (Chidlow et al. 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs); however, no clear aggregation sites have been identified off WA (Chidlow et al. 2006). Given the species' preference for relatively shallow temperate waters, grey nurse sharks are unlikely to be present within the Operational Area but may occur within the wider EMBA.

Great White Shark

The great white shark was identified as potentially occurring within the Operational Area. The species typically occurs in temperate coastal waters between the shore and the 100 m depth contour; however, adults and juveniles have been recorded diving to depths of 1000 m (Bruce et al. 2006, Bruce 2008). They are also known to make open ocean excursions of several hundred kilometres and can cross ocean basins (Weng et al. 2007a, 2007b). Although great white sharks are not known

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to form and defend territories, they are known to return on a seasonal/regular basis to regions with high prey density, such as pinniped colonies (Bruce 2008).

Given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), great white sharks are unlikely to occur within the Operational Area or EMBA.

Shortfin Mako

The shortfin mako was identified as potentially occurring within the Operational Area and EMBA. The shortfin mako shark is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). The shortfin mako is commonly found in water with temperatures greater than 16 °C. The shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana et al. 2005). Tagging studies indicate shortfin makos spend most of their time in water <50 m deep but with occasional dives up to 880 m (Abascal et al. 2011, Stevens et al. 2010). Little is known about the population size and distribution of shortfin mako sharks in WA; however, it is possible they will transit the Operational Area and wider EMBA.

Longfin Mako

The longfin mako was identified as potentially occurring within the Operational Area and EMBA. The longfin mako is a widely distributed, but rarely encountered, oceanic shark species. The species is found in northern Australian waters, from Geraldton in WA to at least Port Stephens in New South Wales (NSW), and is uncommon in Australian waters relative to the shortfin mako (Bruce 2013, DEWHA 2010). There is very little information about these sharks in Australia, with no available population estimates or distribution trends. A study from southern California documented juvenile longfin mako sharks remaining near surface waters, while larger adults were frequently observed at greater maximum depths of about 200 m (Sepulveda et al. 2004). Longfin mako may occur in the Operational Area and broader EMBA, but given their widespread distribution and apparent low density, they are likely to be uncommon.

Scalloped Hammerhead

The scalloped hammerhead is not currently included in the EPBC Act PMST; however, the species is Conservation Dependent under the EPBC Act. Scalloped hammerheads are large sharks which are widely distributed in tropical and subtropical waters, primarily inhabiting shallow coastal shelfs. In Australian waters the species ranges from Geographe Bay in WA, around the northern coast to Wollongong in NSW (Harry et al. 2011). On the east coast of Australia pupping occurs year round, peaking during November and December, with juveniles remaining in shallow inshore habitats (Harry et al. 2011). The species is highly mobile but rarely ventures into deep offshore waters. Scalloped hammerheads are likely to occur within the Operational Area and wider EMBA.

Rays

Reef Manta Ray

The reef manta ray was identified as potentially occurring within the Operational Area. This species is commonly sighted inshore, but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest this species is more resident in tropical waters, and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations than the giant manta ray (Deakos et al. 2011, Marshall et al. 2009). A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier et al. 2011). The Operational Area is in offshore waters, so the area is not considered critical habitat; reef manta rays are considered

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highly unlikely to occur within the Operational Area. However, the reef manta ray may occur in continental shelf waters of the wider EMBA.

Giant Manta Ray

The giant manta ray is broadly distributed in tropical waters of Australia and was identified as potentially occurring within the Operational Area. This species primarily inhabits nearshore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al. 2011). The Operational Area is not located in or adjacent to any known key aggregation areas for the species (e.g. feeding or breeding). However, the Ningaloo Coast, ~278 km south-west of the Operational Area but within the wider EMBA, is an important area for giant manta rays in autumn and winter (Preen et al. 1997). Occurrence of giant manta rays within the Operational Area is likely to be infrequent and restricted to individuals transiting the area.

Pelagic Fish

Southern Bluefin Tuna

The southern bluefin tuna is not currently included in the EPBC Act PMST; however, the species is Conservation Dependent under the EPBC Act. Southern bluefin tuna are highly migratory, occurring throughout waters 30–50° S but mainly in the eastern Indian Ocean and south-western Pacific Ocean. In Australian waters, the species ranges from northern WA, around the southern coast to northern NSW. Juveniles are known to inhabit inshore waters (Honda et al. 2010) and the species is thought to congregate at reefs, lumps and seamounts (Fujioka et al. 2010). Spawning occurs in warm waters south of Java from August–April with a peak during October–February (Honda et al. 2010). Following the spawning period juveniles migrate down to the south coast of WA, with juveniles commonly found in the coastal waters of southern Australia during summer and in deeper, temperate oceanic waters during winter (Bestley et al. 2008, Phillips et al. 2009). Southern bluefin tuna are likely to occur within the Operational Area and EMBA, particularly during summer when juveniles migrate southwards.

4.5.2.8 Birds

Oceanic Seabirds and/or Migratory Shorebirds

The Operational Area may be occasionally visited by migratory and oceanic birds, but does not contain any emergent land that could be used as roosting or nesting habitat and contains no known critical habitats (including feeding) for any species. The NWMR lies within the East Asian-Australasian flyway for migratory birds; species migrating between East Asia and Australia may be present between late spring and early autumn (Table 4-5). Ten species of listed birds were identified by the EPBC Act PMST (Table 4-2) as potentially occurring within the Operational Area (Appendix C):

- common noddy
- common sandpiper
- eastern curlew
- great frigatebird
- lesser frigatebird
- osprey
- pectoral sandpiper
- red knot

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- sharp-tailed sandpiper
- streaked shearwater.

A BIA for the migratory wedge-tailed shearwater overlaps the Operational Area, which is related to breeding between mid-August and April in the Pilbara. Note: The PMST report did not identify wedge-tailed shearwaters within the Operational Area, although it did identify the species may occur in the wider EMBA.

Based on the results of two survey cruises and other unpublished records, Dunlop et al. (1988) recorded the occurrence of 18 species of seabirds over the NWS Province. These included various 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. Migratory shorebirds may be present in or fly through the region between July and December and again between March and April as they complete migrations between Australia and offshore locations (Bamford et al. 2008, Commonwealth of Australia 2015c).

Within the wider EMBA, there are numerous important habitats for seabirds and migratory shorebirds including key breeding/nesting areas, roosting areas and surrounding waters important for foraging, and resting areas within the NWMR. These include (approximate distances from Operational Area to closest emergent feature of area shown in brackets):

- Dampier Archipelago (93 km to Cohen Island)
- Montebello/Barrow/Lowendal Islands group (80, 114, and 103 km to State Nature Reserves/Conservation Parks, respectively)
- Pilbara Islands (North, Middle and South groups – 125, 156, and 233 km to closest State Nature Reserve, respectively)
- Muiron Islands (263 km to State Nature Reserve)
- Rowley Shoals (314 km to State Marine Park)
- Shark Bay (610 km).

These habitats are discussed further as key environmental sensitivities in Section 4.7.

<u>Common Sandpiper</u>

The common sandpiper is listed as migratory under the EPBC Act. The species is a small, migratory sandpiper with a very large range through which it migrates annually between breeding grounds in the northern hemisphere (Europe and Asia) and non-breeding areas in the Asia–Pacific region (Bamford et al. 2008). The species congregates in large flocks and forages in shallow waters and tidal flats between spring and autumn. Specific critical habitat in Australia has not been identified due to the species' broad distribution (Bamford et al. 2008). The common sandpiper may be present in coastal wetland and intertidal sand or mudflats throughout the wider EMBA, although is unlikely to occur in the Operational Area.

<u>Common Noddy</u>

The common noddy is the largest species of noddy found in Australian waters and is listed as migratory under the EPBC Act. The species is widespread in tropical and subtropical areas beyond Australia. This seabird typically forages in coastal waters around nesting sites, taking prey such as small fish, but may occur longer distances out to sea. Nesting occurs broadly across tropical and subtropical Australia in coastal areas, particularly on islands such as the Houtman Abrolhos island group (Burbidge and Fuller 1989). The common noddy is thought to undertake seasonal movements, with some nesting sites abandoned during the non-breeding season (which is protracted between spring and autumn). Based on the information above, the species may occur within the Operational

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Area (although the Operational Area does not constitute critical habitat for the species) and the wider EMBA, particularly around offshore and coastal islands.

Eastern Curlew

The eastern curlew is listed as critically endangered and migratory under the EPBC Act. The eastern curlew is Australia's largest shorebird and a long-haul flyer. The eastern curlew takes an annual migratory flight to Russia and north-eastern China to breed, arriving back home to Australia in August to feed on crabs and molluscs in intertidal mudflats (Bamford et al. 2008). No critical habitats for the eastern curlew have been identified in the Operational Area or wider EMBA.

Great Frigatebird

The greater frigatebird is listed as migratory under the EPBC Act. The species has a circumglobal distribution. The species breeds on offshore islands (generally March to November), and forages in waters surrounding breeding colonies, including Adele Island and Ashmore Reef (DSEWPaC 2012a), which lie beyond the wider EMBA.

Lesser Frigatebird

The lesser frigatebird was identified as potentially occurring within the Operational Area and is listed as migratory under the EPBC Act. It is usually seen in tropical or warmer waters around the coast of northern WA, the Northern Territory (NT), Queensland and northern NSW (DSEWPaC 2012a). Within the NWMR (beyond the wider EMBA) the lesser frigatebird is known to breed on Adele, Bedout and West Lacepede islands, Ashmore Reef and Cartier Islands (DSEWPaC 2012a). The lesser frigatebird feeds mostly on fish and sometimes cephalopods; all food is taken while the bird is in flight. Lesser frigatebirds generally forage close to breeding colonies. A foraging BIA (centred on Bedout Island) is within the wider EMBA, ~167 km east of the Operational Area.

Osprey

The osprey was identified as potentially occurring within the Operational Area and is listed as migratory under the EPBC Act. The osprey is widely distributed around Australia in coastal and wetland habitats (Department of the Environment 2016). The species also occurs throughout south-eastern Asia (Indonesia, Philippines, Palau Islands, New Guinea, Solomon Islands and New Caledonia). Ospreys feed almost exclusively on fish, typically capturing prey observed while flying by plunging feet first into the water (Clancy 2005). While listed as migratory, adults are generally restricted to a foraging area surrounding their nests. Egg laying in Australia is protracted between April and February (Olsen and Marples 1993), which may be due to the extended geographic range of the species within Australia and discrete genetic populations that may constitute subspecies (Olsen and Marples 1993, Wink et al. 2004). Given the species' preference for coastal and wetland environments, it is unlikely to occur within the Operational Area, but may occur within the wider EMBA in coastal waters.

Pectoral Sandpiper

The pectoral sandpiper is listed as migratory under the EPBC Act. As with other species of sandpiper, the pectoral sandpiper breeds in the northern hemisphere during the boreal summer, before migrating long distances to feeding grounds in the southern hemisphere. The species occurs throughout mainland Australia between spring and autumn. The pectoral sandpiper prefers coastal and near-coastal environments such as wetlands, estuaries and mudflats. Given the species' preferred habitat, the pectoral sandpiper is not expected to occur within the Operational Area but is expected to occur in suitable habitats within the wider EMBA.

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Red Knot

The red knot is listed as endangered and migratory under the EPBC Act. This species migrates long distances from breeding grounds in high northern latitudes, where it breeds during the boreal summer, to the southern hemisphere during the austral summer. Both Australia and New Zealand host significant numbers of red knots during their non-breeding period (Bamford et al. 2008). As with other migratory shorebirds, the species occurs in coastal wetland and intertidal sand or mudflats throughout the wider EMBA but is unlikely to occur in the Operational Area due to the lack of suitable habitat.

Sharp-tailed Sandpiper

The sharp-tailed sandpiper is listed as migratory under the EPBC Act. Like other species of sandpiper, the sharp-tailed sandpiper is a migratory wading shorebird and seasonally migrates long distances between breeding grounds in the northern hemisphere and over-wintering areas in the southern hemisphere (Bamford et al. 2008). The species may occur in Australia between spring and autumn. The species is unlikely to occur within the Operational Area due to the lack of suitable habitat but may occur seasonally in coastal wetland and intertidal sand or mudflats throughout the wider EMBA.

Streaked Shearwater

The streaked shearwater is a migratory seabird with a broad distribution in the western Pacific Ocean. The species nests on offshore islands in temperate East Asia, including Japan and the Korean peninsula. During winter months the species migrates south, as far as northern Australia, where is occurs around islands and inshore waters. The species may occur in the Operational Area and wider EMBA during the austral winter.

4.6 Socioeconomic Environment

4.6.1 Cultural and National Heritage

4.6.1.1 European and/or Indigenous Sites of Significance

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

Within the wider EMBA, Ningaloo Reef, Exmouth, Barrow Island, the Montebello Islands and the Dampier Archipelago and adjacent foreshores have a long history of occupancy by Indigenous communities. Indigenous heritage places are protected under the *Aboriginal Heritage Act 1972* (WA) or EPBC Act. A search of the Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System was undertaken for the shoreline within the EMBA (Appendix G). The search indicated there are numerous registered sites, including middens, burial, ceremonial, artefacts, rock shelters, mythological and engraving sites recorded along the Ningaloo Coast (Appendix G). The exact location, access and traditional practices for a number of these sites are not disclosed and, if required (such as in a major hydrocarbon release), further consultation would be prioritised with key contacts within DPLH and local Indigenous communities (refer to Section 5).

4.6.1.2 Underwater Cultural Heritage

In 2018, the Commonwealth *Underwater Cultural Heritage Act 2018* (Underwater Heritage Act) was passed, and came into effect on 1 July 2019, replacing the *Historic Shipwrecks Act 1976*. This new Underwater Heritage Act continues the protection of Australia's shipwrecks, but has also broadened to include protection to sunken aircraft and other types of underwater cultural heritage.

A search of the Australian National Shipwreck Database (Department of the Environment and Energy n.d.), which records all known Maritime Cultural Heritage (shipwrecks, aircraft, relics and

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other underwater cultural heritage) in Australian waters, indicated that there are no known Underwater Cultural Heritage sites within the Operational Area. However, a number of sites were identified within the EMBA; three of these (shipwrecks) were identified within 100 km of the Operational Area (Table 4-7).

Table 4-7: Recorded maritime cultural heritage sites in the vicinity of the Operational Area

Vessel name	Year wrecked	Wreck location*	Latitude (WGS84)	Longitude (WGS84)	Distance from closest point of the Operational Area (km)
McDermott Derrick Barge No 20	1989	North-eastern tip of Eaglehawk Island, Dampier Archipelago	-20.14	115.95	47
McCormack	1989	North-eastern tip of Eaglehawk Island, Dampier	-20.14	115.95	47
Zelma	1990	Dampier Archipelago	-20.38	116.87	96

** Wreck location as recorded in Australian National Shipwreck Database (DoEE n.d.)*

Source: DoEE (n.d.)

4.6.1.3 World, National, and Commonwealth Heritage Listed Places

There are no heritage listed sites within the Operational Area; however, there are a number of gazetted and proposed National and Commonwealth heritage places in the wider EMBA, including:

- World Heritage Places:
  - Ningaloo Coast WHA (~259 km south-west of the Operational Area)
  - Shark Bay WHA (~610 km south-east of the Operational Area)
- National Heritage Places:
  - Dampier Archipelago (including Burrup Peninsula) Indigenous Heritage Place (~93 km south of the Operational Area)
  - Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves Nominated Heritage Place (~73 km south-west of the Operational Area)
  - Ningaloo Coast Natural Heritage Place (~277 km south-west of the Operational Area)
  - Shark Bay Natural Heritage Place (~610 km south of the Operational Area)
- Commonwealth Heritage Places:
  - Ningaloo Marine Area – Commonwealth Waters Natural Heritage Place (~279 km south-west of the Operational Area).

4.6.2 Ramsar Wetlands

No Ramsar wetlands overlap the Operational Area or wider EMBA.

4.6.3 Fisheries – Commercial

4.6.3.1 Commonwealth and State Fisheries

A number of Commonwealth and State fisheries are located within the Operational Area and wider EMBA. Table 4-8 provides further detail on the fisheries that have been identified through desk-based assessment and consultation (Section 5). Figure 4-11, Figure 4-12, and Figure 4-13 show the designated fisheries management areas in relation to the Operational Area.

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Table 4-8: Commonwealth and State fisheries of relevance to the Petroleum Activities Program

Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
Commonwealth Managed Fisheries				
Western Tuna and Billfish Fishery	✓	✓	✓	**Description:** The Western Tuna and Billfish Fishery is currently active, running throughout the year. The fishery zoning extends to the Australian EEZ boundary in the Indian Ocean, overlapping the Operational Area and wider EMBA. The fishery targets four pelagic species, which are all highly mobile: broadbill swordfish (*Xiphias gladius*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), albacore tuna (*T. alalunga*). The number of vessels operating in the fishery has declined in recent years, with less than five vessels operating in the fishery since 2005 (Williams et al. 2017). Data shows fishing effort is concentrated off south-west WA and SA (Williams et al. 2017). The fishing methods used by the fishery are mainly pelagic longline and some minor-line. No significant effort in the vicinity of the Operational Area has been documented. Given the current effort level and recent distribution of effort, it is unlikely fishing by the Western Tuna and Billfish Fishery will occur within the Operational Area or wider EMBA. **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Three vessels (two pelagic longline, one minor longline) (Williams et al. 2017).
Western Skipjack Tuna Fishery	✓	✓	✗	**Description:** The combined Western and Eastern Skipjack Tuna (*Katsuwonus pelamis*) fisheries encompass the entire Australian EEZ, including the Operational Area and wider EMBA. The target species has historically been used for canning, and with the closure of canneries at Eden and Port Lincoln, effort in the fishery has declined and there have been no active vessels operating since 2009 (Patterson and Bath 2017). Given the fishery has been inactive for a number of years, and given the distribution of fishing effort when the fishery was active, fishing for skipjack tuna in the Operational Area is highly unlikely. If the fishery commences efforts in the area in the future, fishing effort in the Operational Area and wider EMBA is considered to be unlikely, given the historical fishery was concentrated off southern Australia. **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Not applicable (fishery inactive) (Australian Fisheries Management Authority [AFMA], 2018). No vessels are active in the fishery.
Southern Bluefin Tuna Fishery	✓	✓	✗	**Description:** The Southern Bluefin Tuna Fishery boundary overlaps the Operational Area, but current effort within the fishery is largely confined to southern Australia, with most effort occurring in the Great Australian Bight (Patterson et al. 2017). Southern bluefin tuna are known to spawn in the north-eastern Indian Ocean (Davis et al. 1990, Matsuura et al. 1997). The species has been heavily exploited by commercial fisheries worldwide.

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
				The fishery employs both longlining and purse seine net fishing methods. Given the current distribution of fishing effort and fishing methods used by the industry, fishing for bluefin tuna is unlikely to occur in the Operational Area or wider EMBA. **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Six purse seine vessels, 16 longline vessels (Australian Bureau of Agricultural and Resource Economics and Sciences 2018).
North-West Slope Trawl Fishery	✗	✓	✗	**Description:** The North West Slope Trawl Fishery (NWSTF) extends from 114 °E to 125 °E, from the 200 m isobath to the outer limit of the Australian Fishing Zone (200 nm from the coastline), which is the boundary of the EEZ. The fishery traditionally targets scampi and deepwater prawns. Fishing for scampi occurs over soft, muddy sediments or sandy habitats, typically at depths of 200–400 m using demersal trawl gear on the continental slope. Activity in the fishery commenced in 1985, peaking at 21 active vessels in 1986–87 (Woodhams and Bath 2017a). There is currently high non-participation among licence holders, and fishing activity has steadily declined since establishing the fishery. Two vessels operated in the fishery in the 2015–16 season, an increase from one vessel in the 2014–15 season (Woodhams and Bath 2017a). The total area of waters fished in 2015–16 did not include the Operational Area, and efforts were focused in waters beyond the 200 m isobath to the north-east of the Operational Area (Woodhams and Bath 2017a). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** 24 km from Operational Area. **Licences/vessels:** Two vessels active in 2015–16 season (Woodhams and Bath 2017a).
Western Deepwater Trawl Fishery	✗	✓	✗	**Description:** The Western Deepwater Trawl Fishery is permitted to operate only in deep waters from the 200 m isobath, as far north as the North West Cape, beyond the Operational Area. This fishery targets a number of deepwater, demersal finfish and crustacean species. The nominated fishing grounds are extensive. However, most of the fishing effort is south and offshore of the North West Cape, with areas of medium- and high-density fishing activity south of Ningaloo Reef and west of Shark Bay, beyond the 200 m isobath (Woodhams and Bath 2017b). No vessels were active in the fishery in the 2014–15 or 2015–16 seasons (Woodhams and Bath 2017b). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** 195 km from Operational Area. **Licences/vessels:** None active in 2015–16 (Woodhams and Bath 2017b), nor 2017–2018 (DoF 2018).

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
State Managed Fisheries				
Pilbara Demersal Scalefish Fishery	✓	✓	✓	**Description:** The State-regulated Pilbara Demersal Scalefish Fishery is managed as part of the North Coast Demersal Scalefish Fisheries and includes the Pilbara Fish Trawl (Interim) Managed Fishery and the Pilbara Trap Managed Fishery. This fishery comprises several management units in the Pilbara and Kimberley regions, targeting a range of low- and high-value finfish species. Gear used in this fishery includes trawl, trap and line fishing, with trawl fishing accounting for the bulk of landings (Newman et al. 2017). The Pilbara Demersal Scalefish Fishery is managed through area closures, gear restrictions and the use individual effort allocations (Newman et al. 2017). The managed fishery boundary overlaps the Operational Area and wider EMBA. The Operational Area overlaps Area 1 and Area 6 of Zone 2, which is open to fishing, including trawl fishing. The Okha FPSO overlaps Area 6 of Zone 2, which has been closed to trawl fishing since 1998. The fishery has had fishing effort over the past 5 years and may be present during petroleum activities. The catch effort in 2018 for trawl was 1780 T, trap was 573 T, and line was 143 T (Department of Primary Industries and Regional Development [DPIRD] 2018). **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** 13 active in 2016 (three trawl, three trap and seven line fishery vessels) (Newman et al. 2017). At least three vessels operate within three separate 10 nm blocks that cover part of the Operational Area; these vessels have operated there for the past five years (DPIRD 2018).
Mackerel Managed Fishery	✓	✓	✓	**Description:** The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*) using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*), with other species from the genera Scomberomorus (Molony et al. 2015). This commercial fishery extends from Geraldton to the NT border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3). Most of the catch is taken from waters off the Kimberley coast (Lewis and Jones 2017), reflecting the tropical distribution of mackerel species (Molony et al. 2015). Most fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area, with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development prior to spawning (Mackie et al. 2003). The catch effort in 2018 was 283 T (DPIRD 2018). Most of the fishing effort is beyond the Operational Area; however, in the past five years, fishing effort in the fishery has overlapped the Operational Area, and may be present during petroleum activities.

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
				Fishery boundary distance from Operational Area: Overlaps Operational Area. **Licences/vessels:** Not stated for 2017–2018 (AFMA 2018); not stated for 2015–16 or 2016–2017 (Lewis and Jones 2017); 14 vessels in 2014 (Molony et al. 2015); 51 licences in 2018 (DPIRD 2018)
Western Australian Abalone Managed Fishery	✓	✓	✗	**Description**: The Western Australian Abalone Fishery includes all coastal waters from the WA–SA border to the WA–NT border. The fishery is concentrated on the south coast (greenlip and brownlip abalone) and the west coast (Roe's abalone). Abalone are harvested by divers, limiting the fishery to shallow waters (typically <30 m). No commercial fishing for abalone north of Moore River (Zone 8 of the managed fishery) has taken place since 2011–2012 (Strain et al. 2017); interactions with participants in the fishery will not occur during the Petroleum Activities Program. The commercial fishery reported a total commercial catch of 49 T in 2016, and 49 T in 2018 (over 404 days) (DPIRD 2018). **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** 26 vessels active in Roe's abalone fishery (Strain et al. 2017); 22 vessels active in Roe's abalone fishery (Strain et al. 2018); 50 licences in 2018 (DPIRD 2018)
Onslow Prawn Managed Fishery	✓	✓	✗	**Description**: The Onslow Prawn Managed Fishery encompasses a portion of the continental shelf off the Pilbara; the managed fishery boundary entirely overlaps the Operational Area and wider EMBA. The fishery targets a range of penaeids (primarily king prawns), which typically inhabit soft sediments in <45 m water depth. Fishing is carried out using trawl gear over unconsolidated sediments (sand and mud). Total prawn catches in 2015 were ~10.1 T, considerably lower than other prawn fisheries (total north coast prawn landings in 2015 were 175 T) (Sporer et al. 2017). Given the water depth of the Operational Area is significantly deeper than the preferred habitat of target species, interaction with participants in the Onslow Prawn Managed Fishery while undertaking the Petroleum Activities Program is very unlikely. Annual landing in 2015 of ~10.1 T. The catch was negligible in the 2015/16 season, at <1 T (Gaughan and Santoro 2018). The catch effort in 2018 was negligible (DPIRD 2018). **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Not specified in Sporer et al. (2017); one vessel (Kangas et al. 2018); 30 licences in 2018 (DPIRD 2018)
Pearl Oyster Managed Fishery	✓	✓	✗	**Description:** The Pearl Oyster Managed Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. Pearl oysters (*Pinctada maxima*) are collected by divers in shallow coastal waters along the NWS and Kimberley, which are mainly used to culture pearls (Hart et al. 2017). The fishery is separated into four zones. The Operational Area overlaps Zone 1, which extends from North West Cape to Cape Thouin. Fishing recently recommenced in Zone 1 after a hiatus of several years (Hart et al. 2017). The portion of the total catch in Zone 1 was minor in 2016–17 (3%) (Hart et al. 2017). Fishing in Zone 1 has occurred as a low

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
				proportion (<1%) of the total annual catch after a hiatus from 2008–2013 (Hart et al. 2018). The catch effort in 2018 was 468,573 oysters (12,845 dive hours) (DPIRD 2018). Given the fishery is diver-based (i.e. restricted to safe diving depths), interaction with fishery participants during the Petroleum Activities Program is very unlikely. **Fishery boundary distance from Permit Area:** Overlaps Operational Area. **Licences/vessels:** 20,445 diver hours (Hart et al. 2017); 6 vessels in 2016; 19,699 diver hours (Hart et al. 2018).
West Coast Deep Sea Crustacean Managed Fishery	✓	✓	✗	**Description**: The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the WA–NT border in water depths >150 m within the Australian Fishing Zone (i.e. EEZ), including the Operational Area. The fishery targets deepwater crustaceans, with most (>99%) of the catch landed in 2015 comprising crystal crabs (How and Yerman 2017). Two vessels operated in the fishery in 2015, using baited pots in a longline formation in the shelf edge waters, mostly in depths between 500 and 800 m (How and Yerman 2017). Fishing effort was concentrated between Fremantle and Carnarvon. Given fishing effort is concentrated beyond the Operational Area, interaction between participants in the fishery during the Petroleum Activities Program are unlikely. The catch effort in 2018 was 153.7 T (DPIRD 2018). **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Two active vessels in 2015 (How and Yerman, 2017); two active vessels in 2016 (How and Yerman, 2018); seven licences in 2018 (DPIRD 2018)
South West Coast Salmon Managed Fishery	✓	✓	✗	**Description**: The South West Coast Salmon Managed Fishery operates on various beaches south of the Perth metropolitan area and includes all WA waters north to Cape Beaufort except Geographe Bay. This fishery uses beach seine nets to take Western Australian salmon (*Arripis truttaceus*). No fishing takes place north of the Perth metropolitan area, despite the managed fishery boundary extending to Cape Beaufort (WA–NT border). Landings in the fishery during 2015 (most recently available statistics) were ~119 T (Smith and Baudains 2017). No interactions with participants in the fishery will occur during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** Overlaps Operational Area. **Licences/vessels:** Not applicable (shore-based); six licences in 2018 (DPIRD 2018)
Marine Aquarium Managed Fishery	✓	✓	✗	**Description:** The Marine Aquarium Fishery can be conducted in State Waters, within the Operational Area and wider EMBA. This fishery is primarily a dive-based fishery that uses hand-held nets to capture target species; it operates from boats up to 8 m long. Therefore, this fishery is unlikely to operate within the Operational Area. The fishery is typically active from Esperance to Broome, with popular areas including the

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
				coastal waters of the Capes region, Dampier and Exmouth. In 2017, eight licenses operated in this fishery. The landed catch was predominantly ornamental fish but also included hermit crabs, seahorses, invertebrates, and corals (Newman et al. 2014). Recent data indicates the fishery has not been active in the Montebello/Barrow Island area since 2013, when less than three vessels were active (DPIRD 2019b). **Fishing boundary distance from the Operational Area:** Overlaps Operational Area. **Licences:** Eleven licences were active in 2016 (Newman et al. 2018).
Specimen Shell Managed Fishery	✓	✓	✗	**Description:** The Specimen Shell Fishery can be conducted in WA State Waters, adjacent to the Operational Area and within the EMBA. This fishery targets specimen shells for display, collection, cataloguing and sale. Collection is predominantly by hand when diving or wading in shallow, coastal waters, though a deeper-water collection aspect to the fishery has been initiated with the use of ROVs operating at depths up to 300 m (Hart and Crowe 2015). The fishery encompasses the entire WA coastline, but effort is concentrated in area adjacent to populated areas such as Broome, Karratha, Shark Bay, Mandurah, Exmouth, Capes area, Albany and Perth (Hart and Crowe 2015), and is therefore unlikely to operate within the Operational Area. This fishery reported a total catch of 8531 shells in 2016, with a catch rate of 10–40 shells per day. **Fishing boundary distance from the Operational Area:** Overlaps the Operational Area. **Vessels:** In 2017 there were 31 licence holders in the fishery, with 23 of these being active in 2016 (Hart et al. 2018c).
Exmouth Gulf Prawn Managed Fishery	✗	✓	✗	**Description**: The Exmouth Gulf Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear within Exmouth Gulf. The target species typically inhabits sandy and muddy substrate in <45 m water depth. The fishery is of high value, with ~1067 T landed in 2015. Exmouth is the main port for participants in the fishery. In the 2016 season, a fishing effort of about 23,000 hours resulted in a catch of 822 T. The fishery is managed based on input controls, temporal closures and spatial closures (Kangas et al. 2017c). The catch effort in 2018 was 713 T (DPIRD 2018). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** ~243 km from Operational Area. **Licences/vessels:** Not specified in Kangas et al. (2017c); six vessels in 2015 (Sporer et al. 2015a); 15 licences in 2018 (DPIRD 2018)
Nickol Bay Prawn	✗	✓	✗	**Description:** The Nickol Bay Prawn Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear. The target species typically inhabits sandy and muddy substrate in <45 m water depth. Landings in the fishery in 2015 were ~87 T, comprised largely of banana prawns (Sporer et al. 2017). Annual

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Fishery	Operational Area	Within wider EMBA	Potential for interaction within Operational Area	Description
Managed Fishery				landing in 2015 of ~87 T. Low effort produced a catch of 17 T in 2016 (Kangas et al. 2018). The catch effort in 2018 was 227 T (DPIRD 2018). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** ~15 km from Operational Area. **Licences/vessels:** Not specified in Sporer et al. (2017); 14 licences in 2018 (DPIRD 2018).
Northern Demersal Scalefish Managed Fishery	✗	✓	✗	**Description**: The Northern Demersal Scalefish Managed Fishery operates off the north-west coast of WA in waters east of 120° E longitude, outside the Operational Area, but within the wider EMBA. The permitted means of operation within the fishery include handline, dropline and fish traps, but since 2002 it has essentially been a trap-based fishery, which uses gear time access and spatial zones as the primary management measures. The main species landed by this fishery are red emperor and goldband snapper (Newman et al. 2017). The catch effort in 2018 was 1317 T (DPIRD 2018). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** ~357 km from Operational Area. **Licences/vessels:** Seven vessels in 2015 (Newman et al. 2017); 15 licences in 2018 (DPIRD 2018).
West Coast Rock Lobster Managed Fishery	✗	✓	✗	**Description**: The West Coast Rock Lobster Fishery targets the western rock lobster (*Panulirus cygnus*) from Shark Bay south to Cape Leeuwin using baited traps (pots). In 2008, it was determined that the allocated shares of the West Coast Rock Lobster resource would be 95% for the commercial sector, 5% to the recreational sector, and one tonne to customary fishers. The commercial fishery has been Australia's most valuable single-species wild capture fishery. In 2012–2013, the fishery moved to an individually transferable quota fishery. The fishery is managed using zones, seasons and total allowable catch. Landings in 2015 were 6416 T (de Lestang and Rossbach 2017). In 2016, 226 vessels reported a total catch of 6086 T (Gaughan and Santoro, 2018). The catch effort in 2018 was 6400 T (DPIRD 2018). Given the fishery lies beyond the Operational Area, interaction with participants in the fishery is not expected during the Petroleum Activities Program. **Fishery boundary distance from Operational Area:** ~247 km from Operational Area. **Licences/vessels:** 230 vessels in 2015 (de Lestang and Rossbach 2017); 226 vessels in 2016 (Gaughan and Santoro,2018); 643 licences in 2018 (DPIRD 2018).

NOTE: The Pilbara Crab Managed Fishery overlaps the Operational Area, but as it was started in late 2018, there is no further information available.

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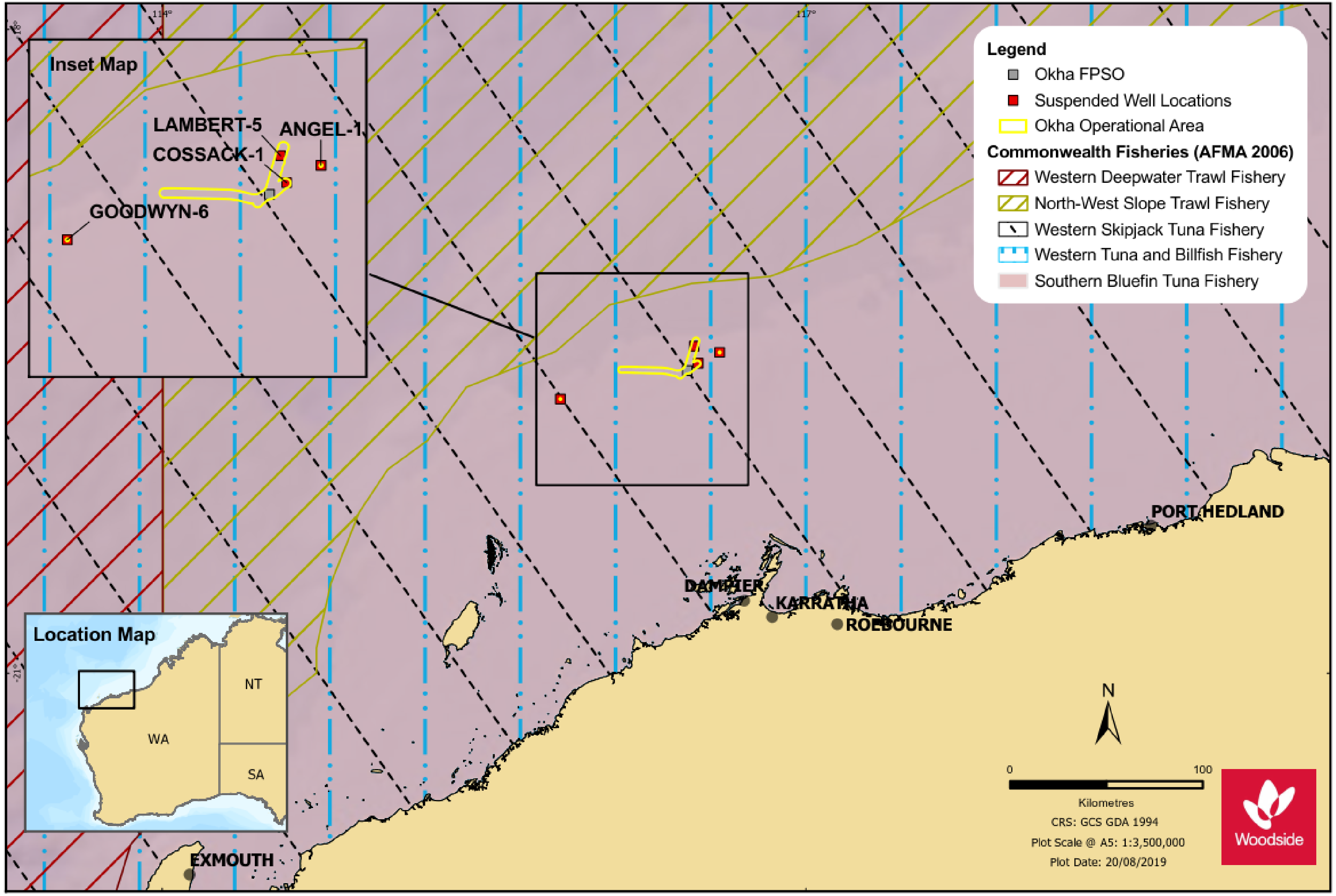

Figure 4-11: Location of Commonwealth fisheries in relation to the Operational Area

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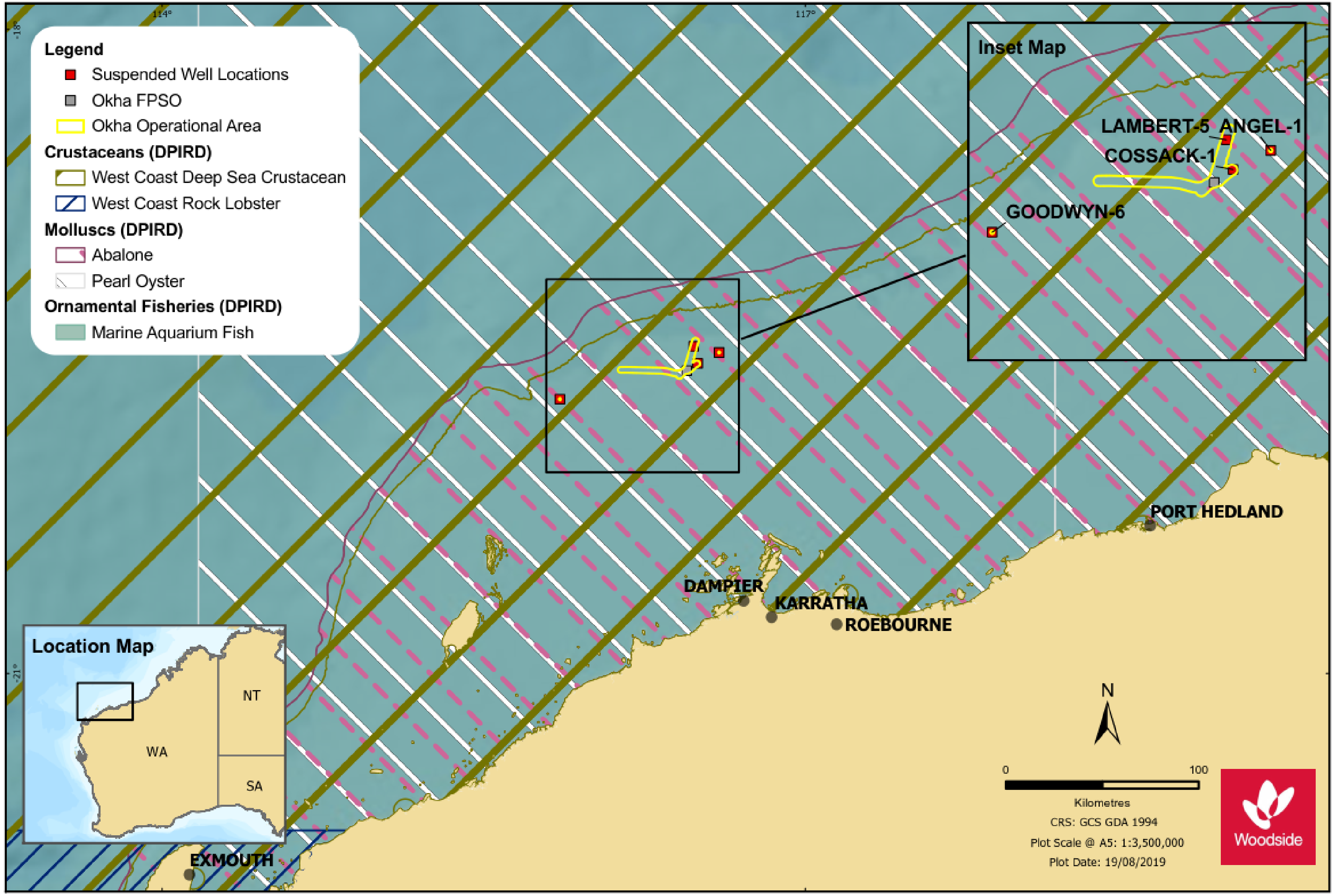

Figure 4-12: Location of State fisheries in relation to the Operational Area

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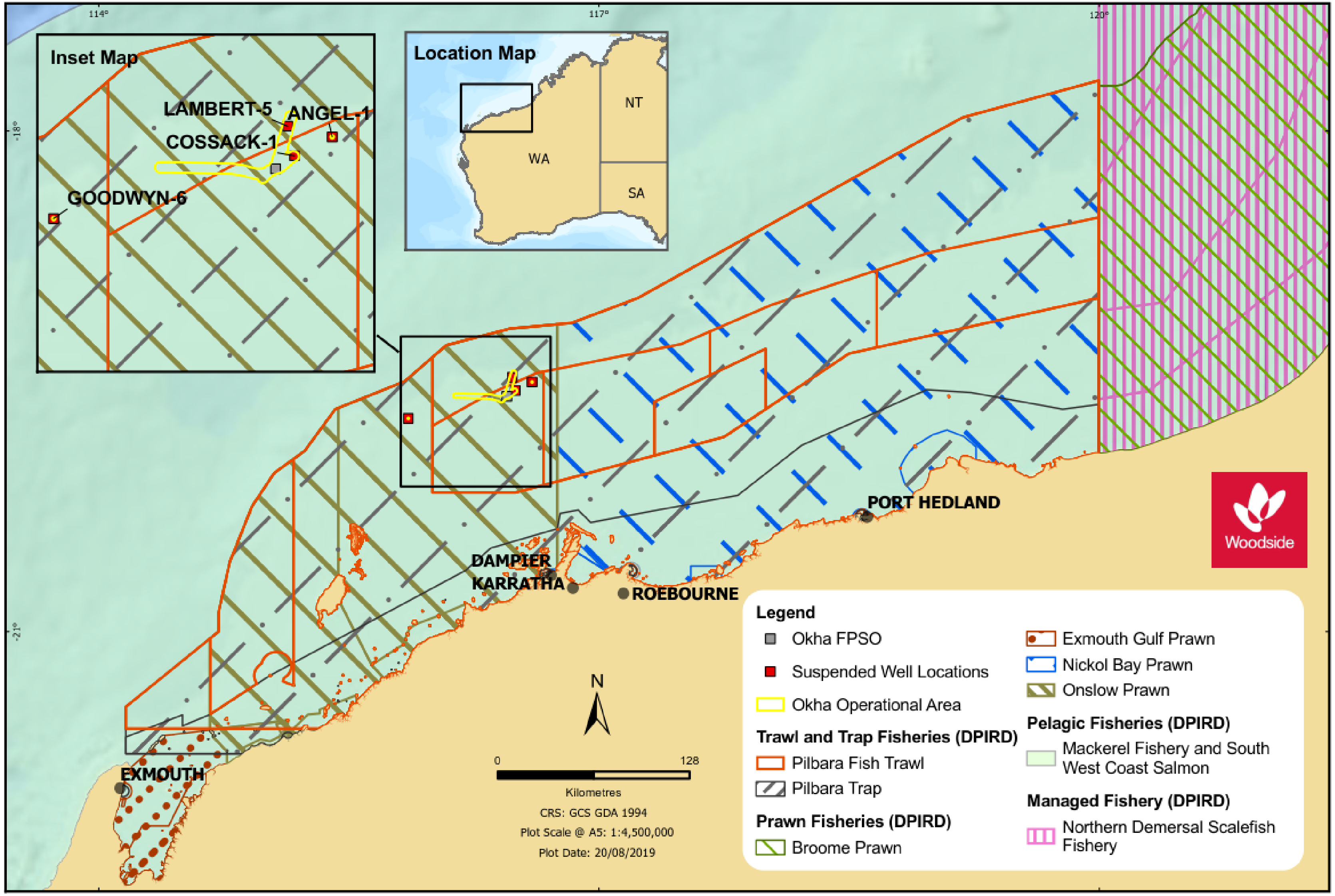

Figure 4-13: Location of State fisheries in relation to the Operational Area

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4.6.3.2 Aquaculture

No aquaculture operations occur within the Operational Area—these operations are typically restricted to shallow coastal waters. Aquaculture in the region consists primarily of culturing hatchery-reared and wild-caught oysters (*Pinctada maxima*) for pearl production, which is primarily centred around Broome and the Dampier Peninsula. Leases typically occur in shallow coastal waters <20 m deep (Fletcher et al. 2006). There are existing pearl aquaculture leases at the Montebello Islands (within the wider EMBA), although they are not currently active (Fletcher et al. 2017).

Pearl oyster spawning primarily occurs from mid-October to December. A smaller secondary spawning occurs in February and March (Fletcher et al. 2006).

4.6.4 Fisheries – Traditional

There are no traditional or customary fisheries within the Operational Area, as these are typically restricted to shallow coastal waters and/or areas with structures such as reefs. However, it is recognised that Barrow Island, Montebello Islands and Ningaloo Reef, all within the wider EMBA, have a known history of fishing when areas were occupied (as evidenced by historical records) (CALM 2005, Department of Environment and Conservation [DEC] 2007).

Traditional fishing still occurs within coastal areas of the Pilbara, particularly within the Dampier Archipelago where there are extensive embayments and islands close to shore. The EMBA overlaps a number of small islands along the offshore extent of the Dampier Archipelago, near Rosemary Island, where there is a potential for traditional fishing to occur, as well as a number of the southern Pilbara islands group (e.g. Thevenard Island, Serrurier Island and Muiron Islands). Although historically traditional fishing occurred on these islands, given their distance from shore it is unlikely to occur today. The EMBA does not overlap any area of mainland within the Pilbara.

4.6.5 Tourism and Recreation

No tourist activities were identified that take place specifically within the Operational Area; however, it is acknowledged that there are growing tourism and recreational sectors in WA which have expanded over the last few decades. Growth and the potential for further expansion in tourism and recreational activities is recognised for the Pilbara and Gascoyne regions, with the development of regional centres and a workforce associated with the resources sector (SGS Economics & Planning 2012).

Tourism is one of the major industries of the Gascoyne region and contributes significantly to the local economy in terms of both income and employment. The main marine nature-based tourist activities are concentrated around and within the Ningaloo WHA (~259 km south-west of the Operational Area) and North West Cape area, including recreational fishing, snorkelling and scuba diving, whale shark (April to August) and manta ray (year round) encounters, whale watching (July to October), whale encounters (August and November) and turtle watching (all year round) (Schianetz et al. 2009). Recreational fishing and diving charters also visit some offshore islands within the EMBA (e.g. Montebello Islands, Thevenard Island [where there is permanent accommodation], Muiron Islands, and islands within the Dampier Archipelago).

4.6.5.1 Ningaloo Coast

Marine nature-based tourism attracts >270,000 annual visitors to the region, with an estimated $127 million AUD spent annually by visitors to the Ningaloo Marine Park and Cape Range National Park (CALM 2005, Jones et al. 2009).

The main marine nature-based tourist activities are snorkelling and scuba diving, whale shark encounters and whale-watching. Most diving takes place relatively close to shore (e.g. Ningaloo and Bundegi Reefs) and around the reefs fringing the offshore islands (e.g. Muiron and Serrurier Islands). Whale-watching and whale shark encounters take place during the seasonal migration/aggregation

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periods, and these activities generally occur within the Ningaloo Marine Park. Coral Bay is one of the most heavily used areas (DEC 2007).

The warm, dry winter climate of the North West Cape area along with accessible fish stocks have made it a focal point for winter recreation by the WA community, and it is frequented by recreational fishers (Smallwood et al. 2011). Recreational fishers predominantly target tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish, with recreational fishing activity peaking between April and October (Smallwood et al. 2011). The highest recreational fishing intensity, based on private boats, is generally centred around the public boat ramps. During 1998–99, between 1500 to 2500 recreational fishing boats were recorded within the vicinity of Bundegi boat ramp, which was the highest recorded along the Ningaloo Coast (DEC 2007).

The charter boat industry in the region has various operators in Exmouth and Coral Bay offering tourists half- and full-day fishing charters; however, there has been no recorded fishing effort from charter vessels in the operational area in the last five years.

4.6.5.2 Shark Bay

Tourism in the Shark Bay area has largely been based on the dolphins at Monkey Mia; however, nature-based tourism has been expanding due to the area's unique ecosystem, land and seascapes, abundant wildlife and cultural values. The region is also a popular destination for recreational fishers. Tourism is a growing industry in the Gascoyne region and makes a major contribution to the local economy. From 2005 to 2007, tourism contributed an estimated $159 million AUD annually to the region's economy (SGS Economics & Planning 2012).

4.6.6 Shipping

The NWMR supports significant commercial shipping activity, most of which is associated with the mining and oil and gas industries (Figure 4-14).

The Australian Maritime Safety Authority (AMSA) has introduced a network of marine fairways across the NWMR to reduce the risk of vessel collisions with offshore infrastructure. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. Note: None of these fairways intersect with the Operational Area (Figure 4-14). Vessel tracking data suggests shipping is concentrated east of the Operational Area, and is likely associated with Woodside oil and gas facilities.

Ports in the region are nodes of increased vessel activities; active ports in the vicinity of the Operational Area include:

- Port of Dampier (~119 km south of the Operational Area)
- Port of Barrow Island (~138 km south of the Operational Area)
- Port of Port Hedland (~234 km south-east of the Operational Area)
- Port of Ashburton, at Onslow (~256 km south-west of the Operational Area).

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

- international bulk freighters/tankers including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers
- domestic support/supply vessels servicing offshore facilities
- construction vessels/barges/dredges
- offshore survey vessels
- commercial and recreational fishing vessels.

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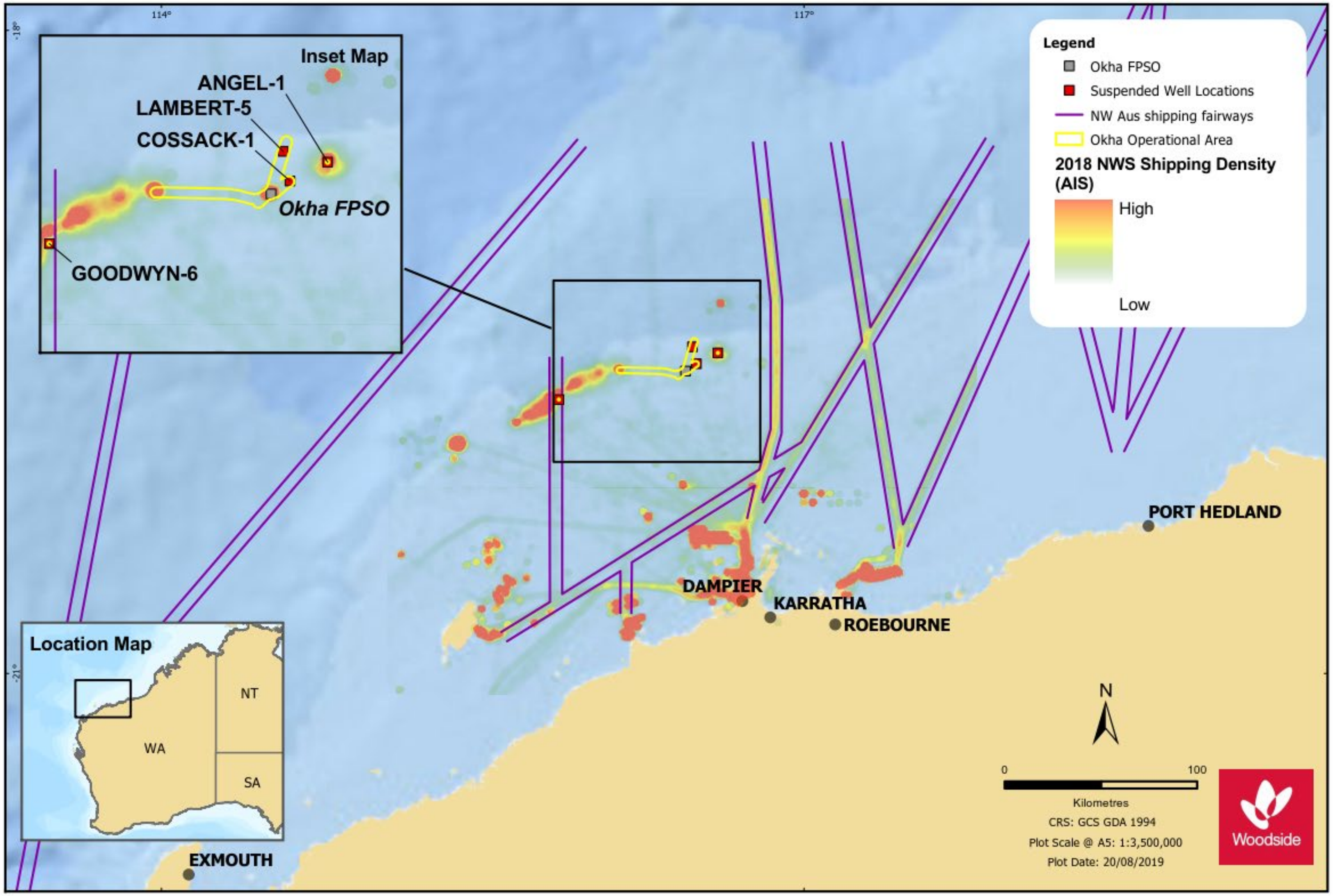

Figure 4-14: Vessel density map in the vicinity of Operational Area from 2016, derived from AMSA satellite tracking system data (vessels include cargo, LNG tanker, passenger, support and other vessels)

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4.6.7 Oil and Gas Infrastructure

The Operational Area is located within an area of established oil and gas operations in the broader NWMR. Table 4-9 lists other facilities (FPSOs and platforms) currently in operation in the vicinity of the Operational Area (as shown in Figure 4-15).

Table 4-9: Other oil and gas facilities in the vicinity of the Operational Area

Facility name (Operator)	Approximate distance from Operational Area (km)	Approximate distance from Okha FPSO (km)	Direction
NRC (Woodside)	Overlapping	32	West
Angel (Woodside)	Overlapping	20	East
GWA (Woodside)	11	54	South-west
Reindeer (Santos)	45	51	South
Stag (Santos)	76	81	South
Wheatstone (Chevron Australia)	55	118	South-west
Pluto (Woodside)	60	122	South-west

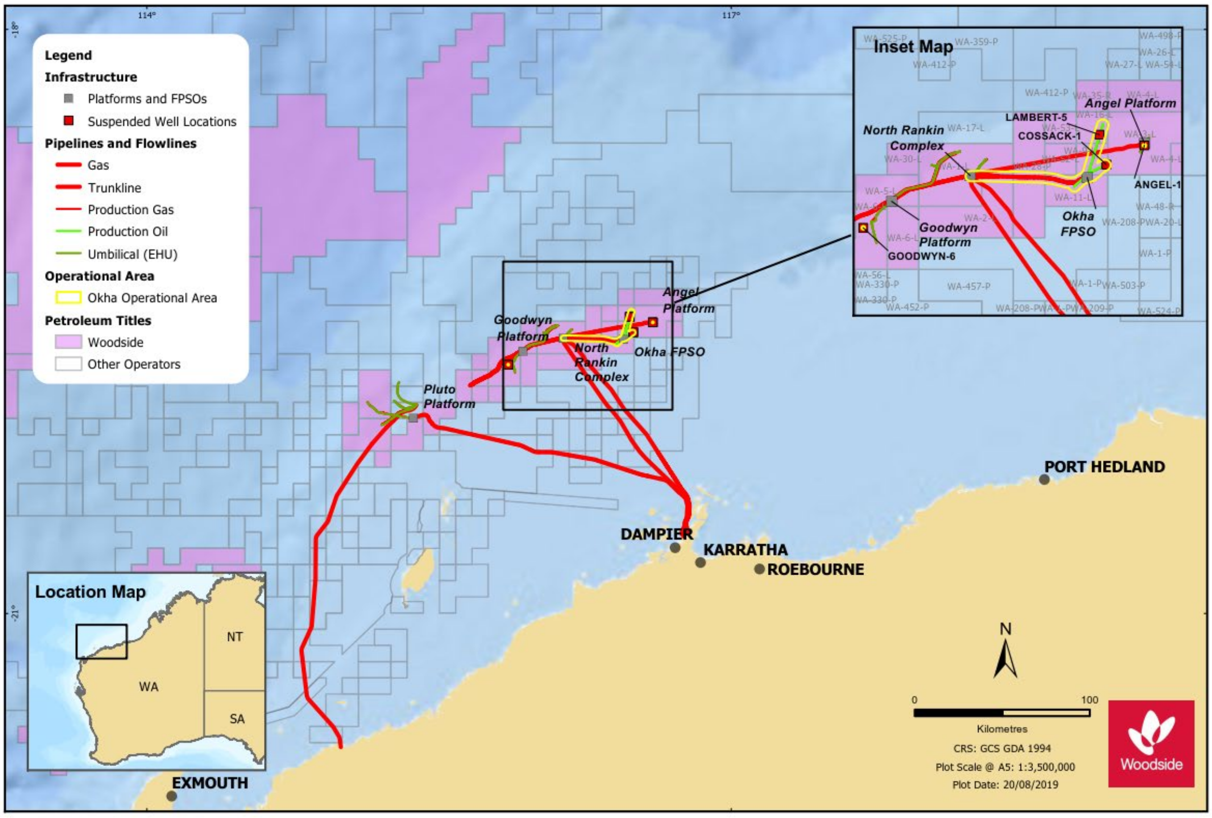

Figure 4-15: Oil and gas infrastructure with reference to the location of the Operational Area

4.6.8 Defence

There are designated defence practice areas in the offshore marine waters off Ningaloo and North West Cape, beyond the Operational Area (Figure 4-16). A Royal Australian Air Force base at Learmonth, on North West Cape, is ~350 km of the Operational Area.

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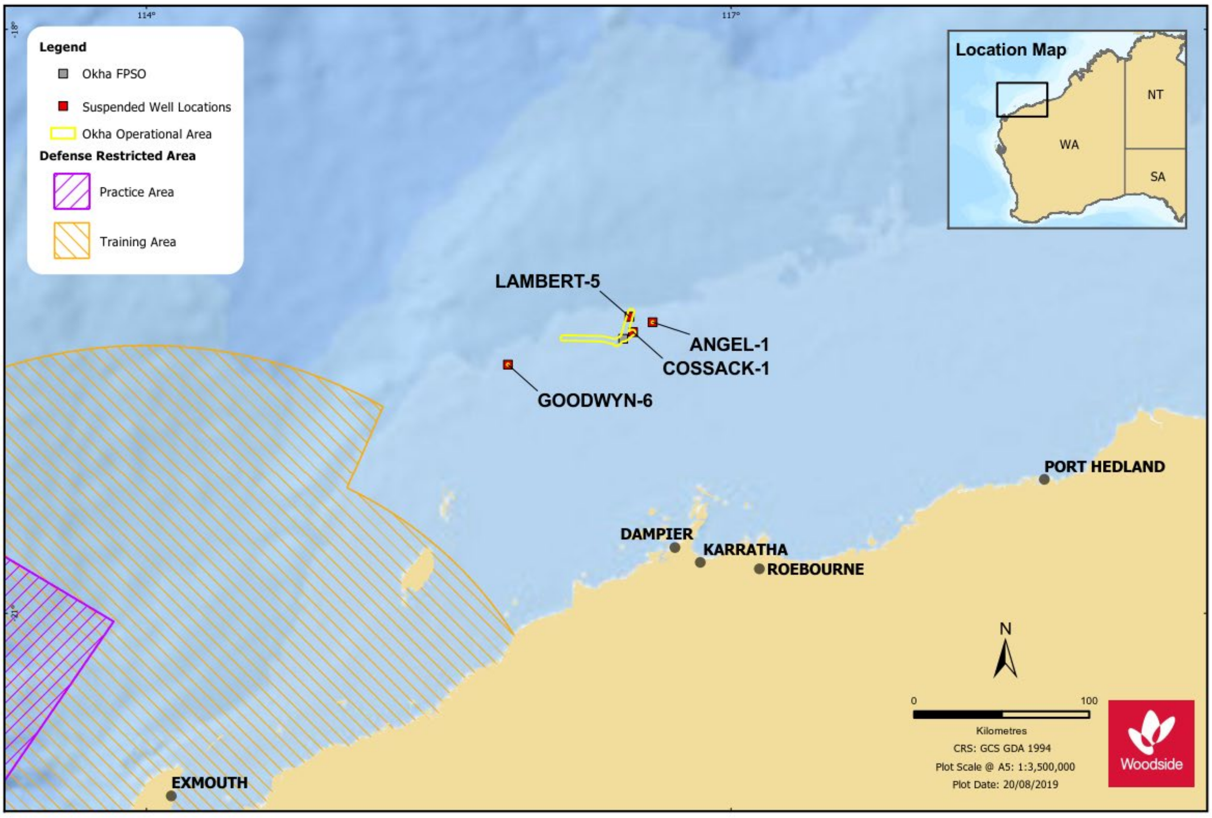

Figure 4-16: Department of Defence demarcated marine offshore areas for military and defence practice with reference to the location of the Operational Area

4.7 Values and Sensitivities

The values and sensitivities of the Operational Area and EMBA are presented in this subsection of the existing environment description. The offshore environment of the NWMR contains environmental assets (such as habitat and species) of high value or sensitivity including Commonwealth offshore waters, as well as the wider regional context including coastal waters and habitats such as the Montebello/Barrow/Lowendal Island Group and the Ningaloo WHA, and the associated resident, temporary or migratory marine life including species such as marine mammals, turtles and birds (Section 4.5.2).

Many sensitive receptor locations are protected as part of Commonwealth and State managed areas and have been allocated conservation objectives (IUCN Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. These principles determine what activities are acceptable within a protected area under the EPBC Act. As all planned petroleum activities will take place within the Operational Area, and no protected areas overlap this, the planned activities associated with the Petroleum Activities Program will be conducted in a manner consistent with the Australian IUCN reserve management principles for the IUCN categories that have been identified (Table 4-10).

The North-west Marine Parks Network Management Plan (DNP 2018) provides for the protection and conservation of biodiversity and values of marine parks in the North-west Region that extends from the WA–NT border to Kalbarri, south of Shark Bay. The North-west Marine Parks Network covers 335,341 km^2 and includes 13 marine parks (DNP 2018).

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Key natural values in the North-west Marine Parks Network Management Plan (DNP 2018) include:

- KEFs (Ashmore Reef, Cartier Island, Canyons linking the Argo Abyssal Plain with the Scott Plateau, Mermaid Reef and the Commonwealth Waters Surrounding the Rowley Shoals, Exmouth Plateau, Canyons linking the Cuvier Abyssal Plain with the Cape Range Peninsula, the Commonwealth Waters adjacent to Ningaloo Reef, Continental Slope Demersal Fish Communities, and the Ancient Coastline at 125 m Depth Contour)
- BIAs where aggregations of individuals of protected species breed, forage and rest during migration.

The North-west Marine Parks Network includes two WHAs, these being the Ningaloo Coast WHA and the Shark Bay, WHA. The plan also supports a range of uses such as shipping, ports, commercial fishing, pearling and aquaculture, as well as offshore mining operations.

A number of high-value or sensitive environments located within the EMBA are part of the North-west Marine Parks Network and management of these is governed by the North-west Marine Parks Network Management Plan (DNP 2018).

The following subsections outline the values and sensitivities of the established and proposed Marine Protected Areas (MPAs) and other sensitive areas in the EMBA (listed in Table 4-10, shown in Figure 4-7). In addition, these areas are also considered in the environmental risk evaluation of planned and unplanned activities associated with the Petroleum Activities Program.

Table 4-10: Summary of established and proposed MPAs and other sensitive locations within the EMBA

	Distance from Operational Area to Values/Sensitivity boundaries (km)	IUCN Protected Area Category[1]
Australian Marine Parks (AMP) (formerly Commonwealth Marine Reserves)		
Montebello[2]	35	VI
Argo-Rowley Terrace[2]	187	II, VI
Gascoyne[2]	250	II, IV, VI
Ningaloo[2]	279	IA
Shark Bay	610	IV
State Marine Parks and Nature Reserves		
Marine Parks		
Montebello Islands	73	IA, II, IV, VI
Barrow Island	124	IA, IV, VI
Ningaloo	279	IA, II, IV
Rowley Shoals	317	II
Shark Bay	610	IA, II
Marine Management Areas		
Barrow Island	94	IA, IV, VI
Muiron Islands	259	IA, VI
Fish Habitat Protection Areas		
None identified within the Operational Area or EMBA		
Nature Reserves		
Lowendal Islands Nature Reserve	103	IA

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	Distance from Operational Area to Values/Sensitivity boundaries (km)	IUCN Protected Area Category[1]
Barrow Island Nature Reserve	114	IA
Heritage		
World Heritage Areas		
The Ningaloo Coast	259	N/A
Shark Bay	610	N/A
National Heritage Areas		
Dampier Archipelago (including Burrup Peninsula)	93	N/A
The Ningaloo Coast	305	N/A
Shark Bay	610	N/A
Commonwealth Heritage Areas		
Ningaloo Marine Area – Commonwealth Waters	277	N/A
Key Ecological Features		
Ancient Coastline at 125 m Depth Contour	Overlapping	N/A
Glomar Shoal	3	N/A
Continental Slope Demersal Fish Communities	40	N/A
Exmouth Plateau	155	N/A
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	231	N/A
Commonwealth Waters adjacent to Ningaloo Reef	278	N/A
Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals	308	N/A

[1] *Conservation objectives for IUCN categories in Table 4-10 include:*

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

[2] *AMPs are part of the North-west Marine Parks Network.*

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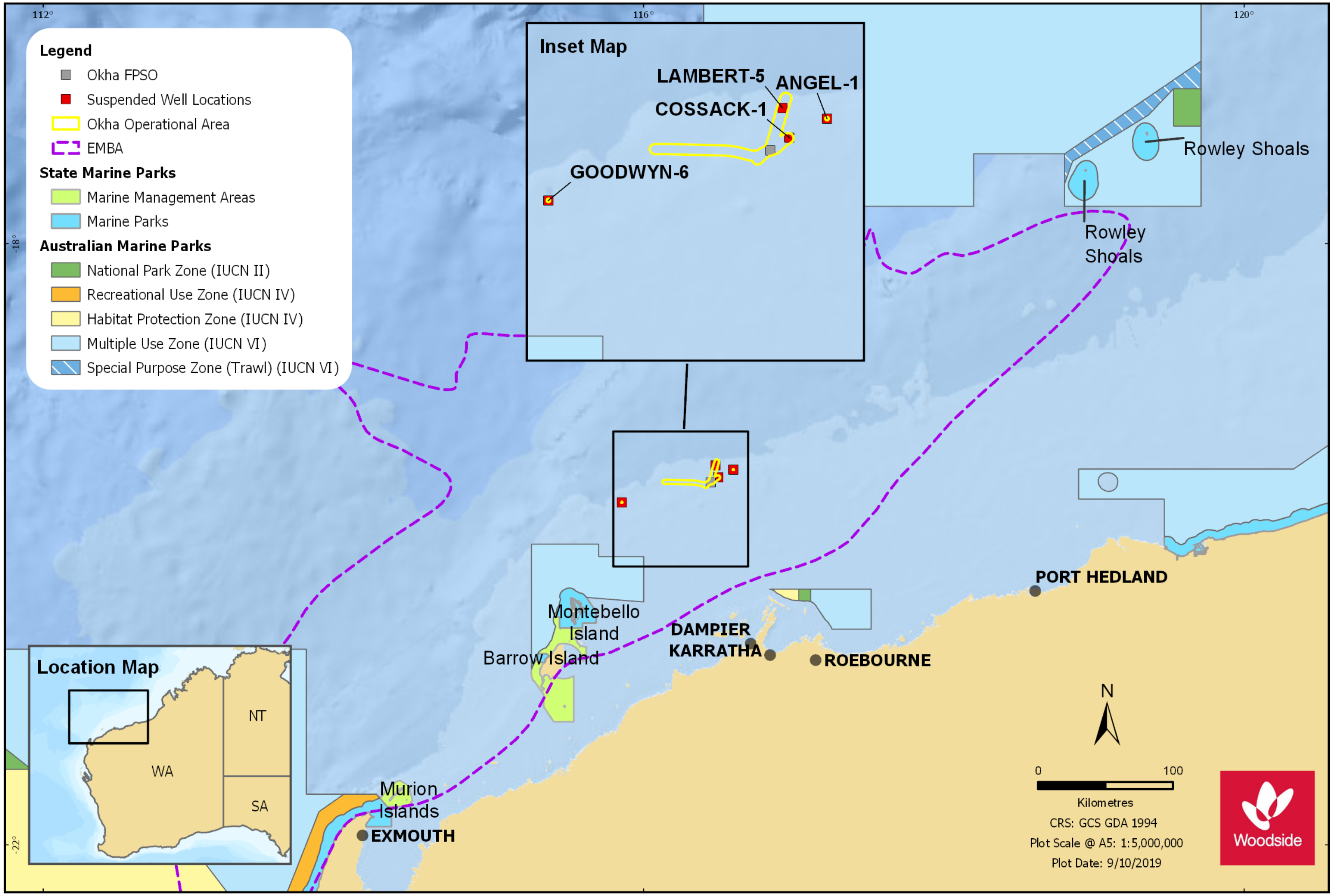

Figure 4-17: Commonwealth and State Marine Protected Areas in relation to the Operational Area

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4.7.1 Montebello/Barrow/Lowendal Islands

The marine and coastal environments of the Montebello/Barrow/Lowendal Islands group represent a unique combination of offshore islands, intertidal and subtidal coral reefs, mangroves, macroalgal communities and sheltered lagoons, and are considered a distinct coastal type with very significant conservation values (DEC 2007).

4.7.1.1 Montebello AMP

The Montebello AMP is adjacent to the Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area, providing a contiguous marine park covering both State and Commonwealth Waters. Major conservation values within the Montebello AMP include (DoEE n.d., DNP 2018):

- habitats, species and ecological communities associated with the NWS Province
- BIAs for a range of MNES, include breeding habitat for seabirds and foraging habitat for whale sharks. (Section 4.5.2)
- two historic shipwrecks, the *Trial* and the *Tanami* (both >100 km from the Operational Area)
- diverse social values including tourism, fishing, mining and recreation
- foraging areas adjacent to important nesting sites for marine turtles
- part of the migratory pathway of the protected humpback whale
- shallow shelf environments with depths ranging from 15 m to 150 m, providing protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features
- examples of the seafloor habitats and communities of the NWS Province bioregion as well as the Pilbara (offshore) mesoscale bioregion (Heap et al. 2005)
- one KEF for the region, the Ancient Coastline at 125 m Depth Contour (Section 4.7.5).

The entire Montebello AMP, an area of 341,300 ha, is designated a multiple use zone (IUCN Category IV), allowing for long-term protection and maintenance of the AMP in conjunction with sustainable use, including oil and gas exploration activities. The Montebello AMP is 35 km from the Operational Area.

The Montebello AMP contains two known shipwrecks; these have been in Australian waters for at least 75 years, and are therefore protected under the Commonwealth *Underwater Cultural Heritage Act 2018*:

- the *Trial*, which was wrecked in 1622, is the earliest known shipwreck in Australian waters
- the *Tanami*, which was wrecked in a cyclone in 1935.

Tourism, commercial fishing, mining and recreation are important activities in the AMP (DNP 2018.

4.7.1.2 Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area

The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area are jointly managed, cover a combined area of 1770 km^2, and are ~73 km from the Operational Area at the closest point. A sanctuary zone covers the entire 4100 ha Barrow Island Marine Park. The Barrow Island Marine Management Area covers 114,500 ha

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and includes most of the waters surrounding Barrow Island and Lowendal Islands, except for the port areas around Barrow and Varanus Islands. Key conservation and environmental values within the reserves include (DEC 2007):

- a complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, cliffs and rocky shores
- pristine sediment and water quality, supporting a healthy marine ecosystem
- undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals
- important mangroves, particularly along the Montebello Islands, which are considered globally unique as they occur in offshore lagoons
- extensive subtidal macroalgal and seagrass communities
- important habitat for cetaceans and dugongs
- nesting habitat for marine turtles
- important feeding, staging and nesting areas for seabirds and migratory shorebirds
- rich finfish fauna with at least 456 species
- historical culture of the pearl oyster (*Pinctada maxima*), which produced some of the highest quality pearls in the world.

These islands support significant colonies of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the biggest breeding population of roseate terns in WA. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. Observations suggest an area to the west of the Montebello Islands may be a minor zone of upwelling in the NWMR, supporting large feeding aggregations of terns. There is also some evidence that the area is an important feeding ground for Hutton's shearwaters and soft-plumaged petrels. Barrow Island is ranked equal tenth among 147 sites in Australia that are important for migratory shorebirds. Barrow, Lowendal and Montebello islands are internationally significant sites for six species of migratory shorebirds, supporting more than 1% of the East Asian-Australasian Flyway population of these species (DSEWPaC 2012c).

The Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area is contiguous with the Montebello Australian Marine Park. The intertidal habitats of the Montebello/Barrow/Lowendal Islands group are influenced by the passage of tropical cyclones that shape sandy beaches (RPS Bowman Bishaw Gorham 2007). The dominant habitats on the exposed west coasts of islands in the area are sandy beaches, rocky shores and cliffs. The predominant physical habitats of the sheltered east coasts of islands are sand flats, mudflats, rocky pavements and platforms (RPS Bowman Bishaw Gorham 2007).

4.7.1.3 Barrow Island Nature Reserve

The Barrow Island Nature Reserve is a Class A Nature Reserve covering ~235 km^2 and extending to the low water mark adjacent to the Montebello Islands/ Barrow Island Marine Parks. The islands surrounding Barrow Island including Boodie, Double, and Middle Islands make up the Boodie, Double, and Middle Islands Nature Reserve, covering 587 ha (Department of Parks and Wildlife [DPaW] 2015). Together, these two nature reserves are commonly referred to as the Barrow Group Nature Reserves (DPaW 2015).

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The Barrow Island coastline comprises dry creek beds, beaches, clay and salt flats, mangroves, intertidal flats and reefs and is bordered by high cliffs on the western side. Key conservation values within the reserves include (DPaW 2015):

- the second largest island off the WA coast
- important biological refuge site because of isolation from certain threatening processes on the mainland
- contains flora that are restricted in distribution and at or near the limit of their range
- high number of fauna species with high conservation value
- extensive hydrogeological karst system that supports a subterranean community of high conservation significance
- regionally and nationally significant rookeries for green and flatback turtles
- important habitat for migratory shorebirds and also used by these species as a staging and destination terminus
- significant habitat values, such as intertidal mudflats, rock platforms, mangroves, rock piles and cliffs, clay pans and caves
- a significant fossil record that indicates local historical biodiversity and evolution
- a history of Indigenous and other European use including 13 registered Indigenous cultural heritage sites.

4.7.1.4 Lowendal Islands Nature Reserve

The Lowendal Islands Nature Reserve incorporates the islands of the Lowendal Archipelago, ~39 km south of Montebello Islands.

The Lowendal Island group is made up of 34 islands and islets, with the largest being Varanus Island at 83 ha. The islands are limestone rocks that extend a few metres above the sea level and have sparse vegetation (DSEWPaC 2012a).

Key conservation values within the reserve include:

- feeding and breeding habitat for the shorebirds including the common greenshank, common sandpiper and the red-necked stint
- foraging habitat for hawksbill turtles
- supports resident populations of common bottlenose dolphins and Indo-Pacific humpback dolphins
- critical nesting and internesting habitat for hawksbill turtles (Varanus Island), and supports an important flatback turtle rookery
- supports seabird colonies for species such as the wedge-tailed shearwaters and bridled terns
- foraging and staging area for migratory shorebirds and internationally significant site for six species of migratory shorebirds, supporting more than 1% of the East Asian-Australasian Flyway population for these species
- provides seagrass habitat for dugongs.

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4.7.2 Ningaloo Coast Gascoyne

4.7.2.1 Ningaloo Coast World Heritage Area

The Ningaloo Coast WHA includes North West Cape and the Muiron Islands, and was inscribed under criterion (vii) and criterion (x) by the World Heritage Committee onto the World Heritage Register in June 2011. The statement of Outstanding Universal Value for the Ningaloo Coast was based on the natural criteria and recognised the following:

- Criterion (vii): The landscapes and seascapes are mostly intact and comprise large-scale marine, coastal and terrestrial environments. The lush and colourful underwater scenery provides a stark and spectacular contrast with the arid and rugged land. Large aggregations of whale sharks and important aggregations of other fish species and marine mammals occur in the Ningaloo Coast WHA. Mass coral spawning and seasonal nutrient upwelling cause a peak in productivity that leads to groups of ~300–500 whale sharks, making this the largest documented aggregation in the world.
- Criterion (x): The Ningaloo Reef harbours a high marine diversity of >300 documented coral species, >700 reef fish species, ~650 mollusc species, as well as ~600 crustacean species and >1000 species of marine algae. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area. In the transition zone between tropical and temperate waters, the Ningaloo Coast hosts an unusual diversity of marine turtle species with an estimated 10,000 nests along the coast annually.

The Ningaloo Coast WHA is recognised as being of outstanding conservation value, supporting a rich array of habitats and diverse and abundant marine life (DoEE n.d.). The region has a high diversity of marine habitats including coastal mangroves, lagoons, coral reef, open ocean, continental slope and the continental shelf (CALM 2005). The dominant feature of the Ningaloo Coast WHA is Ningaloo Reef, the largest fringing reef in Australia. Ningaloo Reef supports both tropical and temperate species of marine fauna and flora, and >300 species of coral (CALM 2005).

The Ningaloo Coast WHA provides important nesting habitat for four species of marine turtle found in WA. The North West Cape and Muiron Islands are major nesting sites for loggerhead turtles, with ~400 and 600 females nesting annually on the Ningaloo Coast (particularly, North West Cape area) and Muiron Islands, respectively. The North West Cape is also a major nesting habitat for hawksbill and green turtles, with ~1000–1500 green turtles nesting in the area annually (DEC 2007). The Muiron Islands are minor nesting sites for flatback and hawksbill turtles (DEC 2007).

Each year, the largest congregation of whale sharks anywhere in the world takes place off the coast of the Ningaloo WHA. It is estimated that between 300 and 500 whale sharks visit each year between March and July, coinciding with the annual mass coral spawning events.

It is these natural heritage values, iconic wilderness, seascapes, wildlife and biodiversity which are major attractions of the WHA and therefore the main driver for tourism on the North West Cape. All properties inscribed on the World Heritage List must have adequate management to ensure their protection, thus the Ningaloo WHA is managed via the Australian Marine Park and State Marine Park (see subsections below).

4.7.2.2 Ningaloo AMP

The Ningaloo AMP covers 2326 km^2 and is ~1200 km north of Perth. It is contiguous with the WA Ningaloo Marine Park. Ningaloo Reef, which is located in State Waters within the State-managed Marine Park, is further protected by the Ningaloo AMP. Water depths range from

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shallow water of 30 m depth to oceanic waters at 1000 m deep. Major conservation values of the park include (DoEE n.d., DNP 2018):

- three KEFs (Section 4.7.5):
  - Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula
  - Commonwealth Waters adjacent to Ningaloo Reef
  - Continental Slope Demersal Fish Communities.
- foraging areas adjacent to important breeding areas for migratory seabirds, whale sharks and marine turtles
- important nesting sites for marine turtles
- part of the migratory pathway of the humpback whale
- shallow shelf environments with depths ranging from 15 m to 150 m, providing protection for the shelf and slope habitats, as well as pinnacle and terrace seafloor features
- examples of the seafloor habitats and communities of the Central Western Shelf Transition.

The park has international and national significance due to its diverse range of marine species and unique geomorphic features. It provides essential biological and ecological links that sustain the biodiversity and ecological processes, including the supply of nutrients to reef communities from deeper waters further offshore, to the Ningaloo Reef ecosystem.

The Ningaloo AMP (Commonwealth Waters) Management Plan outlines objectives for retaining the values of this protected area and any potential or confirmed threats that could impact these values. Values that could be impacted from the Petroleum Activities Program and the associated management objectives (goals and strategies) in the Management Plan are outlined in Table 4-11. Note: Each management objective in the plan relates only to a source of risk, rather than the value potentially impacted, and is therefore generic for all Petroleum Activities.

Table 4-11: Relevant key threats and management objectives from the Ningaloo AMP (Commonwealth Waters) Management Plan

Value potentially impacted by Petroleum Activities Program	Relevant existing and potential threats identified in Management Plan	Associated management objectives (strategies/goals)	Relevant EP section
Physical values			
High water quality	Pollution: • contaminants and marine debris arising from petroleum or mineral exploration and production • oil/chemical spill from shipping accident	Management goal – to prevent adverse impacts on the physical, ecological, social and cultural values of the Commonwealth Waters from petroleum or mining activities in the vicinity of Ningaloo AMP. Management strategies – maintain the exclusion of petroleum and mineral exploration and production from Commonwealth Waters	Credible risks and impacts to these receptors are considered in Section 6.8

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Value potentially impacted by Petroleum Activities Program	Relevant existing and potential threats identified in Management Plan	Associated management objectives (strategies/goals)	Relevant EP section
Ecological values			
High water quality	• Petroleum or mineral exploration and production activities including seismic operations • Pollution (see above)	Management goal – to prevent adverse impacts on the physical, ecological, social and cultural values of the Commonwealth Waters from petroleum or mining activities in the vicinity of Ningaloo AMP. Management strategies – maintain the exclusion of petroleum and mineral exploration and production from Commonwealth Waters	Credible risks and impacts to these receptors are considered in Section 6.8
Marine mammals and fish (e.g. whales; dugong; whale sharks)	Oil/chemical spill		
Marine reptiles (e.g. turtles)	Oil/chemical spill		
Seabirds	Oil/chemical spill		
Social values			
• Major destination for recreational fishers • Recreational boating and yachting • Destination for nature based tourism (e.g. diving/ fishing, whale shark/ marine life viewing/ interaction tours)	Reduced amenity resulting from major oil/chemical spill	Management goal – to prevent adverse impacts on the physical, ecological, social and cultural values of the Commonwealth Waters from petroleum or mining activities in the vicinity of Ningaloo AMP. Management strategies – maintain the exclusion of petroleum and mineral exploration and production from Commonwealth Waters	Credible risks and impacts to these receptors are considered in Section 6.8

4.7.2.3 Ningaloo Marine Park and Muiron Islands Marine Management Plan

The Ningaloo Marine Park (State Waters) was established in 1987 and stretches 300 km from the North West Cape to Red Bluff. It encompasses the State Waters covering the Ningaloo Reef system and a 40 m strip along the upper shore. The Muiron Islands Marine Management Area is managed under the same management plan as for the Ningaloo State Marine Park (CALM 2005). The Ningaloo Marine Park is part of the Ningaloo Coast WHA. Ecological and conservation values of the Ningaloo Marine Park and Muiron Islands are summarised below.

Generally, all ecological values are presumed to be in an undisturbed condition except for some localised high-use areas (CALM 2005). The ecological and conservation values include:

- unique geomorphology, which has resulted in a high habitat and species diversity
- high sediment and water quality
- subtidal and intertidal coral reef communities providing food, settlement substrate and shelter for marine flora and fauna
- filter feeding communities (sponge gardens) in the northern part of the North West Cape and the Muiron and Sunday Islands

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- shoreline intertidal reef communities providing feeding habitat for larger fish and other marine animals during high tide
- soft sediment communities found in deeper waters, characterised by a surface film of microorganisms that provide a rich source of food for invertebrates
- macroalgae and seagrass communities, which are an important primary producer providing habitat for vertebrate and invertebrate fauna
- mangroves occurring only in the northern part of the Ningaloo Marine Park, important for reef fish communities (Cassata and Collins 2008) and supporting a high diversity of infauna, particularly molluscs (600 mollusc species)
- diverse fish fauna (~460 species)
- foreshores and nearshore reefs of the Ningaloo coast and Muiron/Sunday islands providing internesting, nesting and hatchling habitat for several species of marine turtles including the loggerhead, green, flatback and hawksbill turtles
- whale sharks aggregating annually to feed in the waters around Ningaloo Reef, from March to July, with the largest numbers being recorded around April and May (Sleeman et al. 2010). The season can be variable, with individual whale sharks being recorded at other times of the year. Timing of the whale sharks' migration to and from Ningaloo coincides with the mass coral spawning period when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef
- seasonal shark aggregations and manta rays, commonly found in the area with a permanent population of manta rays (*Manta alfredi*) inhabiting the Ningaloo Reef. Numbers are boosted periodically by roaming and seasonal animals. Small aggregations coincide with small pulses of target prey and the spawning events of many reef inhabitants, while larger aggregations coincide with major seasonal spawning events. The number of species in the Ningaloo Reef area peaks during autumn, which corresponds to coral spawning, and during spring which corresponds with the crab spawning event (McGregor n.d.)
- annual mass coral spawning on Ningaloo Reef. Synchronous, multi-species spawning of tropical reef corals occurs during a brief predictable period in late summer/early autumn generally seven to nine nights after a full moon on neap, nocturnal ebb tides March/April each year (Rosser and Gilmour 2008, Taylor and Pearce 1999)
- large coral slicks generally forming over shallow reef areas in calm conditions. Note: Minor spawning activities occur on the same nights after the February and April full moons, and in some years the mass spawning event occurs after the April full moon (Simpson et al. 1993)
- marine mammals such as dugong and small cetacean populations frequenting or residing in nearshore waters. Dugong numbers in Ningaloo Marine Park are considered to be ~1000 individuals, with a similar number in Exmouth Gulf (CALM 2005). The Ningaloo/Exmouth Gulf region supports a significant population of dugongs, which is interconnected with the Shark Bay resident
- nesting and foraging habitat for seabirds and shorebirds. Approximately 33 species of seabirds are recorded in the Ningaloo Marine Park (13 resident and 20 migratory), with five known rookeries as well as isolated rookeries on the Muiron and Sunday Islands.

In addition to the ecological and conservation values, the Ningaloo Marine Park has a number of social values including culture heritage (both Indigenous and maritime; Section 4.6.1) and marine-based tourism and recreation (water-sports and fishing) (Section 4.6.5). The Ningaloo

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Marine Park (State Waters) is contiguous with the Ningaloo AMP (Figure 4-17) and The Ningaloo Coast was listed as a National Heritage Place on 6 January 2010 due to its extraordinary natural qualities and Indigenous Significance (DoEE 2019b).

Ningaloo Shoreline, Shallow Subtidal Reef and Intertidal Habitats

The Ningaloo Marine Park reef and lagoonal systems comprise a variety of shallow subtidal and intertidal communities that contain shallow outer reef slope (spur and groove habitat), reef crest (emergent at low tide), reef flat (coralline algae and high cover tabular *Acropora* spp. coral communities), back reef lagoon (coral, soft sediment and macro-algal communities), sublittoral limestone platform (turf algae/molluscs/echinoderm community), and intertidal mangrove, mudflat and salt marsh communities (Cassata and Collins 2008).

The area seaward of the reef crest is characterised by a coralline algae/coral community (spur and groove reef slope). The area has a series of perpendicular spur and grooves from 5 to 40 m depth range, comprising narrow, deep channels filled with sand and coral rubble and rock spurs with diverse hard coral communities (with dominant tabular *Acropora* spp. growing in small, compact colonies), together with soft corals, *Millepora* spp. (fire coral), sponges and macroalgae. Coralline algae encrust dead corals, rocks and coral rubble. Coral growth is most prolific between 5 and 10 m depth.

On the landward side of the reef crest is a reef flat habitat and back reef lagoon, with various subtidal and intertidal habitats (Cassata and Collins 2008):

- outer reef flat (very shallow, <1 m depth) at the back of the reef crest: Coralline algae/coral community (spur and groove). Similar morphology to the reef slope
- rocky middle/inner reef flat (~1 m depth): Tabular *Acropora* spp. community
- back reef lagoon (>2 m depth): Patchy staghorn, massive and sub-massive coral community
- lagoonal sand flat (1–2 m depth): Sparse corals and algae community. This habitat is characterised by sheltered areas of limestone pavement with a veneer of sand and small outcrops of corals (Porites spp., Acropora spp.) with scattered patches of macroalgae (Sargassum spp., Halimeda spp., Caulerpa spp.) or seagrass (Halophila spp.)
- lagoonal and inter-reef sandy depressions (3–15 m depth): Coral ‘bommies’ and algal patch community; a distinctive habitat type composed of sandy depressions either found as large deep regions within the lagoon or small depressions/channels inside the reef flat
- lagoon, shoreward reef channels (shallow): Macroalgal community. Fleshy algae colonising subtidal limestone pavement that is covered in sand with Sargassum spp. up to 0.5 m high and other red and green algal species. There are also small patches of hard and soft corals, sponges and ascidians
- sublittoral limestone platform: Turf algae/mollusc/echinoderm community. This habitat is composed of a flat limestone pavement often contiguous with the rocky shoreline, and supports intertidal and subtidal fauna comprising molluscs (limpets, chitons, small mussels, cowries and giant clams) and echinoderms (sea cucumbers, starfish and sea urchins) with isolated hard and soft coral colonies. The limestone pavement also has a ubiquitous coverage of turf algae
- mangroves: Although not a common habitat type within Ningaloo Marine Park, there are mangroves in the upper intertidal zone on a muddy substrate of carbonate silt and lay. The mangroves are located within the mangrove sanctuary zone (where they occupy a large section of coast between Low Point and Mangrove Bay) and sporadically within the osprey sanctuary zone on the Yardie Creek banks. There are three species of mangrove:

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Avicennia marina, *Rhizophora stylosa* and *Bruguiera exaristata*. *A. marina* is most common and widespread. This habitat supports a diverse community of invertebrate fauna including gastropods, crabs and burrowing worms, and is also a nursery area for the juveniles of many species of reef fish

- intertidal mudflats: Mudflats occur in the lower intertidal zone of the lagoon, formed from the deposition of mud in the sheltered tidal waters
- salt marshes: The salt marsh habitat is seaward of the mangroves and is represented by salt tolerant vegetation and sandy patches.

In addition to the ecological and conservation values, the Ningaloo Marine Park has a number of social values including cultural heritage (both Indigenous and maritime; Section 4.6.1) and marine-based tourism and recreation (water sports and fishing; Section 4.6.5). The Ningaloo Marine Park (State Waters) is contiguous with the Ningaloo AMP (Commonwealth Waters).

The Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area outlines objectives for retaining the values of this protected area and any potential or existing threats that could impact these values. Values that could be impacted from the Petroleum Activities Program and the associated management objectives outlined in the Management Plan are detailed in Table 4-12.

Table 4-12: Relevant key threats and management objectives from the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area

Value potentially impacted by Petroleum Activities Program	Relevant existing and potential threats identified in Management Plan	Associated management objectives	Relevant EP section
Ecological values			
Water quality	No explicit threats from hydrocarbon spill, i.e.: • toxicant inputs from the accidental spillage of fuel and oils, or • hydrocarbon spills from passing ships	To ensure that the water quality of the reserves is maintained at a level that supports and maintains the areas ecological and social values.	Credible risks and impacts to these receptors are considered in Section 6.8
Coral reef communities	Pollution events (shipping, oil/gas industry)	To ensure the diversity and abundance of coral reef communities in the reserves are not significantly impacted by human activities within the reserves.	
Shoreline and Intertidal communities	Pollution events (shipping, oil/gas industry)	To ensure the diversity and abundance of shoreline intertidal reef communities in the reserves are not significantly impacted by trampling and recreational collecting within the reserves	
Macroalgal and seagrass communities	Pollution events (shipping, oil/gas industry)	To ensure seagrass and macroalgal communities are not disturbed as a result of human activities in the reserves.	
Mangrove communities	Pollution events (shipping, oil/gas industry)	To ensure the species diversity and abundance of mangrove communities within the Park are not significantly impacted by trampling.	

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Value potentially impacted by Petroleum Activities Program	Relevant existing and potential threats identified in Management Plan	Associated management objectives	Relevant EP section
Seabirds, shorebirds and migratory waders	Pollution events (shipping, oil/gas industry)	To ensure the species diversity and abundance of seabird, shorebird and migratory bird species in the reserves are not significantly impacted by human activity.	
Social values			
No specific threats/management objectives identified for the Petroleum Activities Program			

Muiron Islands: Shallow Subtidal, Intertidal and Shoreline Habitats

Coastal sensitivity mapping identified the onshore sensitivities to be turtle rookeries and turtle nesting, which occurs from October to April (Joint Carnarvon Basin Operators 2012). Most of the western coast comprises limestone coastal cliffs interspersed with sandy beaches and intertidal rock platforms. The nearshore sensitivities include the intertidal/nearshore reef (Joint Carnarvon Basin Operators 2012). Soft coral communities dominate the reefs on the western side of the Muiron Islands. Habitats on the eastern side are more sheltered, comprising sandy beaches and shallow lagoons with diverse soft and hard coral communities (Cassata and Collins 2008, Kobryn et al. 2013).

4.7.2.4 Gascoyne AMP

The Gascoyne AMP covers ~81,766 km^2 and includes waters from <15 m to 6000 m deep. Conservation values identified within the park include (DoEE n.d., DNP 2018):

- foraging areas for migratory seabirds (including the wedge-tailed shearwater), hawksbill and flatback turtles and whale sharks
- a continuous connectivity corridor
- seafloor features including canyon, terrace, ridge, knolls, deep hole/valley and continental rise
- sponge gardens in the south of the park adjacent to WA coastal waters
- examples of the ecosystems of the Central Western Shelf Transition, the Central Western Transition and the NWS Province bioregions as well as the Ningaloo mesoscale bioregion.

The park contains three key conservation values for the region:

- canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula (associated enhanced productivity, aggregations of marine life and unique seafloor feature)
- Exmouth Plateau (unique seafloor feature associated with internal wave generation)
- continental slope demersal fish communities (high species diversity and endemism; this is the most diverse slope bioregion in Australia, with >500 species recorded, of which 76 are endemic to the area).

The park boundary is adjacent to the existing Commonwealth portion of the Ningaloo AMP.

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4.7.3 Pilbara Coast and Islands

4.7.3.1 Dampier Archipelago (including Burrup Peninsula) National Heritage Place

The Dampier Archipelago, which is ~1550 km north of Perth, was included on the National Heritage List on 3 July 2007 (DoEE n.d.). The National Heritage Place is ~36,860 ha, with the Burrup Peninsula comprising ~400 km^2 (DoEE 2019). The Burrup Peninsula is made up of islands, reefs, shoals, channels and straits. The National Heritage Place includes Australia's greatest collection of petroglyphs and a high density of stone sites (DoEE n.d.). The rock engravings illustrate the evolution of societies and the environment over time, including engravings of humans, animals and geometric designs (DoEE n.d.). The stone arrangements include standing stones, stone pits and circular stone arrangements.

4.7.3.2 Pilbara Islands (Northern, Middle and Southern Island Groups)

Within the nearshore waters between the Muiron Islands and the Dampier Archipelago are a series of islands collectively termed the Northern, Middle and Southern Island Groups. This area has been defined as the Pilbara offshore region (>10 m water depth) and includes islands, shoals and rocky outcrops.

The Northern Island Group includes more than 30 islands that range from east of Cape Preston south to the mouth of the Robe River, 10–35 km offshore, including the Great Sandy Islands Nature Reserve and the Passage Islands. The Northern Island Group is ~125 km south-south-west of the Operational Area.

The Middle Island Group, which is ~156 km south of the Operational Area, includes the Mary Anne Reefs and neighbouring small islands. The Southern Island Group includes Serrurier, Bessieres and Thevenard Islands Nature Reserves and is ~233 km south-west of the Operational Area. The nearshore habitats of these islands generally comprise fringing reefs on the seaward side and wide intertidal sand flats on the leeward side. Despite generally high turbidity in the area and relatively low abundance, hard coral biodiversity is high (Chevron Australia 2010). The coral community structure within this area, and others within the region, is highly temporally variable due to cyclonic activity.

The large islands of the groups provide important nesting habitat for seabirds and marine turtles (Chevron Australia 2010). In the Southern Island Group, a number of seabirds, including Caspian terns, little terns, wedge-tailed shearwaters and ospreys breed on Serrurier Island and nearby Airlie Island. Wedge-tailed shearwaters also have breeding populations on islands from the Northern Island Group. Hawksbill turtle feeding grounds occur in the Mary Anne and Great Sandy Island groups. Mary Anne Island also includes a breeding population of roseate terns. Serrurier Island also is a major nesting area for green turtles and may be a foraging area for this species. Thevenard Island supports a significant flatback turtle rookery along with small numbers of green turtles and is a known feeding area for green turtles.

Chevron Australia (2010) documented the key subtidal habitats of the Pilbara offshore region as:

- limestone pavement supporting dense macroalgae
- biogenic fringing coral reefs
- coral communities associated with hard substrate (shoals and rocky outcrops)
- filter feeding communities (sponges and ascidians) on sand veneered pavement
- sand/gravel plains and shoals supporting sparse foliose macroalgae.

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4.7.4 Rowley Shoals

4.7.4.1 Rowley Shoals Marine Park

The Rowley Shoals Marine Park protects two of the three oceanic shoals (Clerke Reef and Imperieuse Reef) that constitute the Rowley Shoals. The third shoal (Mermaid Reef) is protected by the Argo-Rowley Terrace AMP (see below). The Rowley Shoals Marine Park is characterised by intertidal and subtidal coral reefs, with rich and diverse marine fauna and high water quality. The reefs within the park may act as a source of recruits for habitats further south, via the Leeuwin Current, and hence are considered to be regionally significant (Marine Parks and Reserves Authority [MPRA] 2007). Environmental values within the Rowley Shoals Marine Park include (MPRA 2007):

- geology and geomorphology: the best geological examples of shelf-edge atolls on the Australian continental shelf, with the three reefs representing three distinct stages in formation
- water quality: high water quality due to the relatively low seasonal human usage and the surrounding pristine oceanic waters
- intertidal coral reef communities: extensive relatively undisturbed intertidal coral reef communities with a high diversity of marine fauna
- subtidal coral reef communities: coral communities dominated by a rich diversity of hard corals
- invertebrates (excluding corals): a diverse marine invertebrate community that includes a number of endemic species
- finfish: a rich finfish fauna that includes many species unique to Australia
- turtles: turtles occur within the park, but no known significant breeding sites
- seabirds: Bedwell Island within Clerke Reef is the site of the second largest breeding colony of red-tailed tropic birds, an uncommon species in WA
- cetaceans: based on known distributions, it is likely that at least 13 species of cetaceans regularly visit the park
- scientific research: the undisturbed nature and rich diversity of marine communities provide researchers with access to a reference area with which to compare the health of intensively used reefs in the Indo-West Pacific region
- scuba diving, snorkelling and other water sports: the relatively undisturbed nature and diversity of the natural environment provides world-class opportunities for scuba diving and snorkelling
- seascapes: ‘wilderness’ seascapes of turquoise lagoon waters, low sandy islands, intertidal reefs, breaking surf and the oceanic waters beyond the reef rim are major attractions
- nature-based tourism: natural values of the area ensure significant tourism potential and opportunity for a variety of marine nature-based tourism activities
- recreational fishing: a popular offshore fishing destination, with fishers primarily targeting pelagic and, to a lesser degree, demersal finfish species
- petroleum exploration and production: the Rowley sub-basin of the Canning Basin (over which the Rowley Shoals are located) is considered to be prospective for petroleum

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- wilderness: a remote and isolated location with minimal infrastructure and low visitor levels provides a wilderness experience for visitors.

The marine park is located in the headwaters of the Leeuwin Current and is thought to provide a source of invertebrate and fish recruitment for reefs further south and thus is considered regionally important (MPRA 2007). Marine turtles are known to visit Mermaid Reef, and isolated instances of turtles nesting in the Rowley Shoals Marine Park have been recorded (DEWHA 2008).

The Rowley Shoals are also identified as breeding grounds for red-tailed tropicbirds, white-tailed tropicbirds and little terns; however, numbers are generally low (e.g. only a single pair of white-tailed tropic birds nest on Bedwell Island on Clerke Reef [DSEWPaC 2012b]).

4.7.4.2 Argo-Rowley Terrace AMP

The Argo-Rowley Terrace AMP covers 146,099 km^2 of the MPA network, including the Commonwealth Waters surrounding the Rowley Shoals (each reef is managed as separate State and Australian marine parks). The Argo-Rowley Terrace AMP encompasses water depths from ~220 m to 6000 m.

The ecological and conservation values include (DoEE n.d., DNP 2018):

- important foraging areas for migratory seabirds and, reportedly, the loggerhead turtle
- support for relatively large populations of sharks (compared with other areas in the region)
- a range of seafloor features such as canyons, continental rise and the terrace, among others
- two KEFs (Section 4.7.5):
  - Canyons linking the Argo Abyssal Plain with the Scott Plateau
  - Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals
- connectivity between the reefs of the Rowley Shoals
- linkage of the Argo Abyssal Plain with the Scott Plateau through canyons.

4.7.5 Key Ecological Features

KEFs are the parts of the marine ecosystem that are considered to be important for a marine region's biodiversity or ecosystem function and integrity. KEFs have been identified by the Commonwealth Government on the basis of advice from scientists about the ecological processes and characteristics of the area.

KEFs meet one or more of the following criteria:

- a species, group of species or a community with a regionally important ecological role (e.g. a predator, prey that affects a large biomass or number of other marine species)
- a species, group of species or a community that is nationally or regionally important for biodiversity
- an area or habitat that is nationally or regionally important for:
  - enhanced or high productivity (such as predictable upwellings – an upwelling occurs when cold nutrient-rich waters from the bottom of the ocean rise to the surface)
  - aggregations of marine life (such as feeding, resting, breeding or nursery areas)

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- biodiversity and endemism (species which only occur in a specific area), or
- a unique seafloor feature, with known or presumed ecological properties of regional significance.

One KEF overlaps the Operational Area, with an additional five KEFs within or intersecting the EMBA (Table 4-11 and Figure 4-18).

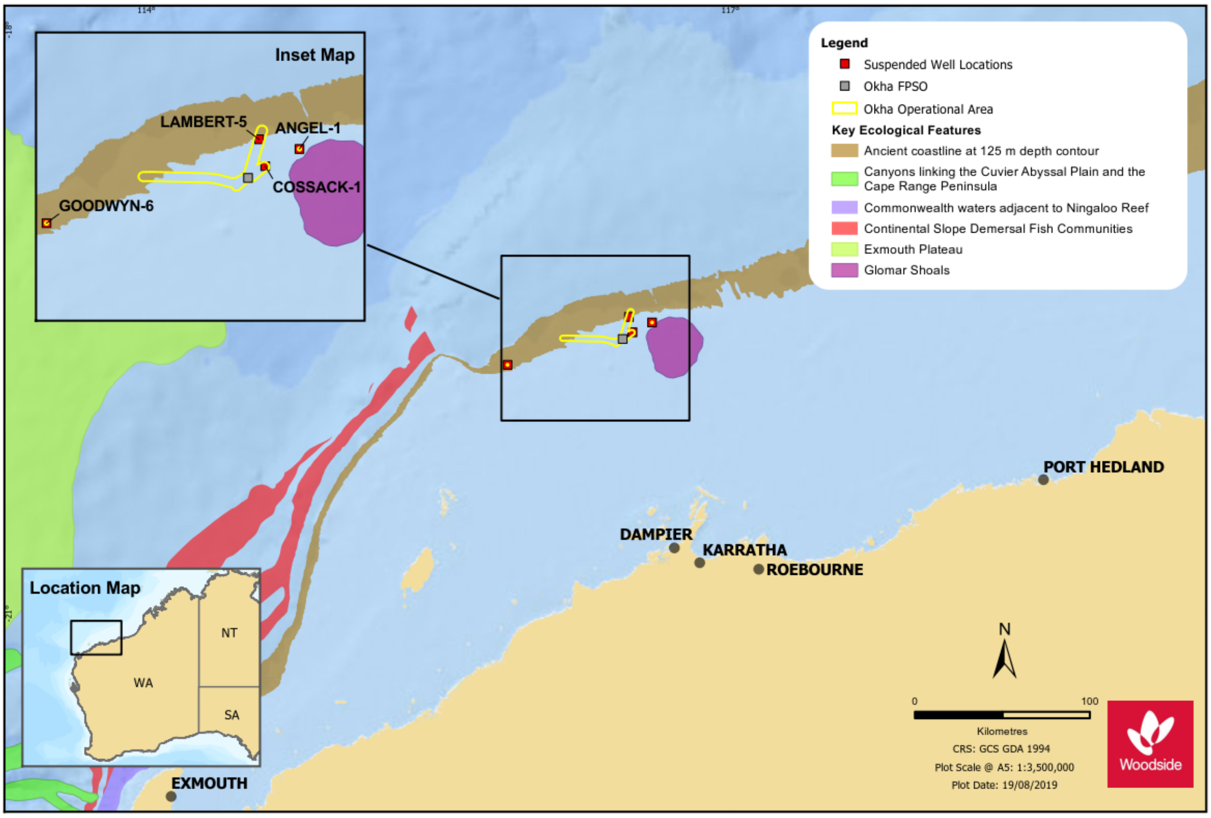

Figure 4-18: Key ecological features in relation to the Operational Area

4.7.5.1 Ancient Coastline at 125 m Depth Contour

Several steps and terraces as a result of Holocene sea level changes occur in the region with the most prominent of these features occurring as an escarpment along the NWMR and Sahul Shelf at a water depth of 125 m, which forms the Ancient Coastline at 125 m Depth Contour KEF (the ancient coastline). The Ancient Coastline KEF overlaps the Operational Area, extending along a line approximated by the 125 m isobath (Figure 4-18). The ancient coastline is not continuous throughout the NWMR, and coincides with a well-documented eustatic stillstand at ~130 m worldwide (Falkner et al. 2009b).

Where the ancient coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (Falkner et al. 2009b). Parts of the ancient coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment.

The escarpment type features may also potentially facilitate mixing within the water column due to upwelling, providing a nutrient-rich environment. Although the ancient coastline adds additional habitat types to a representative system, these habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner et al. 2009b).

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4.7.5.2 Continental Slope Demersal Fish Communities

The continental slope demersal fish communities in the region have been identified as a KEF of the NWS Province (DSEWPaC 2012a); they are ~40 km west of the Operational Area. The continental slope between North West Cape and the Montebello Trough has been identified as one of the most diverse slope assemblages in Australian waters, with >508 fish species and the highest number of endemic species (76) of any Australian slope habitat (DEWHA 2008). Additional features relating to the fish populations of this area are:

- Continental slope demersal fish communities have been identified as a KEF of the NWMR due to the notable diversity of the demersal fish assemblages and high levels of endemism (DSEWPaC 2012a).
- The North West Cape 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 (Last et al. 2005). The benthic shelf and slope communities offshore the North West Cape comprise both tropical and temperate fish species with a north−south gradient (DEWHA 2008).

The fish fauna of the North West Cape region, like the ichthyofauna of many regions, exhibit decreasing species richness with depth (Last et al. 2005). 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 (Gratwicke and Speight 2005). A total of 500 finfish species from 234 genera and 86 families have been recorded within the Ningaloo Marine Park, and 393 species were identified at study sites of the Muiron Islands (CALM 2005). The offshore sediment habitats of the Operational Area are expected to support lower fish species richness than other shallower, more complex habitats in the coastal areas of the region.

4.7.5.3 Glomar Shoal

Glomar Shoal is ~3 km south-east of the Operational Area. This submerged shoal is a large (215 km^2) complex bathymetrical feature on the outer continental shelf off the Pilbara. Glomar Shoal rises gently on the south-west side of the reef from 80 m depth to a single plateau at 40 m depth. The north-eastern side of the reef rises steeply from 70 m to 40 m depth. The shoal is relatively shallow, with water depths reaching 22–28 m at its shallowest point. Together with Rankin Bank, this remote shallow-water area represent regionally unique habitats and is likely to play an important role in the productivity of the Pilbara region (AIMS 2014b, Wahab et al. 2018).

Glomar Shoal has been identified as a KEF of the continental shelf within the NWMR, based on its regionally important habitat supporting high biological diversity and high localised productivity (Falkner et al. 2009). On a regional level, Glomar Shoal is also known to be an important area for a number of commercial and recreational fish species.

Benthic habitats of Glomar Shoal vary with depth and are characterised by coarse unconsolidated sediment at depths >60 m to hard substrate supporting benthic communities comprising spare hard and soft corals sponges and macroalgae at depths <40 m. Total cover of benthic taxa (hard coral, soft coral, sponges and other benthic biota) is highest at depths <40 m and decreases with depth (Wahub et al. 2018). At depths of 60–80 m benthic cover is low and ~2%, and at depths >80 m benthic cover is barely present with baseline survey data indicating 0.1% cover of benthic biota. The results of a baseline survey and habitat modelling undertaken by AIMS in 2013 indicate that the portion of Glomar Shoal overlapping the Operational Area comprises soft sediment seabed and not areas of higher, phototrophic benthic biota (AIMS 2014). Structurally complex biodiverse benthic habitats are mainly found within the north-eastern portion of Glomar Shoal (AIMS 2014, Wahab et al. 2018).

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Overall, the benthic habitats of Glomar Shoal are considered pristine and host regionally distinct ecological communities. The fish abundance and diversity of the demersal fish communities of Glomar Shoal is influenced by the seabed habitat type, with genera associated with sandy habitats common, including threadfin breams (*Nemipterus* spp.) and triggerfish (*Abalistes* spp.). Species richness and abundance are influenced by habitat depth and the degree of coral cover. In general, the fish abundance and diversity of Glomar Shoal is considered comparable with other reefs and the submerged shoals and banks in the region, although less diverse and abundant than fish assemblages at Rankin Bank (Wahab et al. 2018).

4.7.5.4 Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals

Mermaid Reef and the Commonwealth Waters surrounding the Rowley Shoals KEF is ~308 km from the Operational Area, adjacent to the three nautical mile State Waters limit surrounding Clerke and Imperieuse reefs; it includes the Mermaid Reef National Nature Park (Section 4.7.5).

4.7.5.5 Exmouth Plateau

The Exmouth Plateau is a large, mid-slope, continental margin plateau off the north-west coast of Australia, ~155 km west of the Operational Area. It ranges in depth from ~800 m to 3500 m and is a major structural element of the Carnarvon Basin (Miyazaki and Stagg 2013). The plateau is bordered by the Exmouth sub-basin of the Northern Carnarvon Basin to the east, the Argo Abyssal Plain to the north, and the Gascoyne and Cuvier Abyssal Plains to the north-west and south-west.

The Exmouth Plateau is overlaid by an interface between the ITF and the Indian Ocean central water. This interface constitutes a potential shear zone (with associated mixing) and may display substantial temporal variability, both seasonally and in response to longer term changes such as ITF variability (Brewer et al. 2007). Internal tides are strongest between January and March (Brewer et al. 2007). Satellite observations suggest that productivity is enhanced along the northern and southern boundaries of the plateau and along the shelf edge, which in turn suggests the plateau is a significant contributor to the productivity of the region (Brewer et al. 2007). The seascape of the Exmouth Plateau is not considered to be unique by Falkner et al. (2009) in their review of KEFs in the NWMR; however, the geological origin (Exon and Willcox 1980) and potential enhanced upwelling due to the Exmouth Plateau (Brewer et al. 2007) may constitute unique environmental values (DSEWPaC 2012a).

Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton (Brewer et al. 2007). Protected and migratory species (including whale sharks and cetaceans) are also known to pass through the region.

Most actions in or adjacent to the NWMR are considered unlikely to adversely impact upon the integrity or ecosystem function of the Exmouth Plateau; ocean acidification resulting from climate change is the only potential pressure identified in the relevant bioregional plan (DSEWPaC 2012a).

4.7.5.6 Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula

The canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF (the Canyons KEF) are off the north-west coast of Australia, ~231 km south-west of the Operational Area. The canyons are believed to support the productivity and species richness of Ningaloo Reef (DSEWPaC 2012a). Interactions with the Leeuwin current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al. 2007). As a result, aggregations of whale

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sharks, manta rays, humpback whales, sea snakes, sharks, predatory fish and seabirds are known to occur in the area due to the enhanced productivity (Sleeman et al. 2007). Note: Upwelling may not result from the presence of the canyons, but from other factors such as local wind stress (e.g. upwelling off the Capes region in south-western Australia) and internal waves (Taylor and Pearce 1999, Woo et al. 2006).

Falkner et al. (2009) identified that canyons functioning as a conduit between the continental shelf and deep ocean were considered to be important. Such conduits provide a pathway for shelf production to be transported to the deep sea, as observed in river canyons. However, given the Enfield canyon is a 'blind' canyon (i.e. formed by slumping of shelf and slope sediments rather than river canyon), it may not provide this conduit function. Falkner et al. (2009) noted that canyons may facilitate upwelling of nutrient-rich water, which is consistent with the observed upwelling associated with the Ningaloo Current; however, alternative explanations supported by metocean observation and modelling studies have been put forward (e.g. local wind stress [Woo et al. 2006] and internal wave action [Taylor and Pearce 1999]). Additionally, given the depth of the head of the Enfield canyon (>200 m), there is little potential for benthic primary production on the continental shelf to be advected to the deep sea, which has been identified as an ecological function of river canyons with shallow heads (Falkner et al. 2009, Vetter and Dayton 1999).

Given KEFs are identified based on their regional importance or ecosystem function/integrity, the Enfield canyon does not appear significantly different than the surrounding region, with seabed habitats and deepwater biota being typical and representative in the wider region. A pressure analysis of threats to the Canyons KEF did not identify any threats of concern but identified ocean acidification as being of potential concern (DoEE n.d.).

4.7.5.7 Commonwealth Waters Adjacent to Ningaloo Reef

The Commonwealth Waters adjacent to Ningaloo Reef KEF are ~278 km from the Operational Area and are adjacent to the three nautical mile State Waters limit along Ningaloo Reef. The KEF includes the Ningaloo AMP. See Section 4.7.2 for further information about the values and sensitivities associated with this KEF.

4.7.6 Other Sensitive Areas

4.7.6.1 Rankin Bank

Rankin Bank is on the continental shelf, ~21 km east of the Operational Area at the closest point. While Rankin Bank is not a KEF, it is, along with Glomar Shoal, the only large complex bathymetrical feature on the outer western shelf of the west Pilbara, and represents habitats that are likely to play an important role in the productivity and biodiversity of the Pilbara region (AIMS 2014b, Wahab et al. 2018). Rankin Bank comprises three submerged shoals delineated by the 50 m depth contour with water depths of ~18–30.5 m (AIMS 2014b).

Rankin Bank represents a diverse marine environment, predominantly comprising consolidated reef and algae habitat (~55% cover), followed by hard corals (~25% cover), unconsolidated sand/silt habitat (~16% cover), and benthic communities composed of macroalgae, soft corals, sponges and other invertebrates (~3% cover) (AIMS 2014b). Hard corals are a significant component of the benthic community of some parts of the bank, with abundance in the upper end of the range observed elsewhere on the submerged shoals and banks of north-west Australia, and have been shown to be more diverse and productive than those at Glomar Shoal (Heyward et al. 2012, Wahab et al. 2018).

Rankin Bank has been shown to support a diverse fish assemblage (AIMS 2014b); Wahab et al. (2018) suggested Rankin Bank is a refuge for fish species on the largely homogeneous

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benthic habitat in the middle to outer continental shelf in the NWS Province (Wahab et al. 2018). Rankin Bank has been shown to host more abundant and species-rich fish assemblages than Glomar Shoal, although differences in some measures of taxonomic diversity and distinctness were not significantly different (Wahab et al. 2018). This is consistent with studies showing a strong correlation between habitat diversity and fish assemblage species richness (Gratwicke and Speight 2005, Last et al. 2005).

The habitat surrounding Rankin Bank (<50 m deep) was mapped by AIMS on behalf of Woodside (2014c) and hosts filter feeding communities in areas of consolidated substrate interspersed by sand. Refer to Section 4.5.1.4 for information on filter feeding communities.

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5. STAKEHOLDER CONSULTATION

5.1 Summary

Woodside is committed to consulting relevant stakeholders to ensure stakeholder feedback informs its decision making and planning for proposed petroleum activities and builds upon Woodside's extensive and ongoing stakeholder consultation for its offshore petroleum activities in the region.

5.2 Stakeholder Consultation Guidance

Woodside has followed the requirements of Subregulation 11A (1) of the Environment Regulations to identify relevant stakeholders, these being:

- Each Department or agency of the Commonwealth Government to which the activities to be carried out under the Environment Plan, or the revision of the Plan, may be relevant.
- Each Department or agency of a State or the NT Government to which the activities to be carried out under the Environment Plan, or the revision of the Plan, may be relevant.
- The Department of the responsible State Minister, or the responsible NT Minister.
- A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the Environment Plan, or the revision of the Plan.
- Any other person or organisation that the Titleholder considers relevant.

Woodside's assessment of stakeholder relevance is outlined in Table 5-1.

5.3 Stakeholder Consultation Objectives

In support of this EP, Woodside has sought to:

- ensure all relevant stakeholders are identified and engaged in a timely and effective manner
- develop and make available communications material to stakeholders that is relevant to their interests and information needs
- incorporate stakeholder feedback into the management of the proposed activity where practicable
- provide feedback to stakeholders on Woodside's assessment of their feedback and keep a record of all engagements
- make available opportunities to provide feedback during the life of this EP.

5.4 Stakeholder Expectations for Consultation

Stakeholder consultation for this activity has also been guided by stakeholder organisation expectations for consultation on planned activities. This guidance includes:

NOPSEMA:

- *GL1721 - Environment plan decision making - Rev 5 - June 2018*
- *GN1847 - Responding to public comment on environment plans - Rev 0 - April 2019*
- *GN1344 - Environment plan content requirements - Rev 4 - April 2019*
- *GN1488 - Oil pollution risk management - Rev 2 - February 2018*

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Commonwealth Government:

- *Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area*

AFMA:

- *Petroleum industry consultation with the commercial fishing industry*

Commonwealth Department of Agriculture and Water Resources:

- *Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006*
- *Offshore Installations Biosecurity Guide*

WA Department of Primary Industries and Regional Development:

- *Guidance statement for oil and gas industry consultation with the Department of Fisheries*

WA Department of Transport

- *Offshore Petroleum Industry Guidance Note*

Woodside acknowledges that additional relevant stakeholders may be identified prior to or during the proposed activity. These stakeholders will be contacted, provided relevant information to their interests and invited to provide feedback about the proposed activity. Woodside will assess their feedback, respond to the stakeholder and incorporate feedback into the management of the proposed activity where practicable.

Woodside consultation arrangements typically provide stakeholders up to 30 days (unless otherwise agreed) to review and respond to proposed activities where stakeholders are potentially affected. Woodside considers this consultation period an adequate timeframe in which stakeholders can assess potential impacts of the proposed activity and provide feedback.

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Table 5-1: Assessment of relevant stakeholders for the proposed activity

Stakeholder	Relevant to activity	Reasoning
Commonwealth Government department or agency		
Australian Customs Service – Border Protection Command (ACS)	Yes	Responsible for coordinating maritime security.
Australian Fisheries Management Authority (AFMA)	Yes	Responsible for managing Commonwealth fisheries. There has been no recent effort by Commonwealth fishery licence holders in the area.
Australian Hydrographic Service (AHS)	Yes	Responsible for maritime safety and Notice to Mariners.
Australian Maritime Safety Authority (AMSA)	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth Waters.
Department of Agriculture and Water Resources (DAWR)	Yes	Responsible for implementing Commonwealth policies and programs to support the agriculture, fisheries, food and forestry industries. Although the proposed activity is unlikely to impact Commonwealth fisheries as fishing effort has historically occurred outside the Operational Area (Table 4-8), Woodside notes DAWR’s interest in biosecurity matters, such as the introduction of invasive marine species (IMS), and has provided information about the proposed activity.
Department of Defence	No	The Operational Area is not within a Defence activity area.
Department of the Environment and Energy (DoEE)	No	Responsible for designing and implementing Commonwealth policy and programs to protect and conserve the environment, water and heritage, promote climate action, and provide adequate, reliable and affordable energy. The proposed activity does not trigger any of the DoEE’s functions, interests or activities.
Department of Industry, Innovation and Science (DIIS)	Yes	Required to be consulted under the Regulations.
Director of National Parks (DNP)	No	Responsible for managing AMPs. Although planned activities do not affect the functions, interests or activities of DNP, Woodside notes DNP’s interest in unplanned activities, such as an oil spill and has provided information about the proposed activity.
WA Government department or agency		
Department of Biodiversity, Conservation and Attractions(DBCA), Parks and Wildlife Service	No	Responsible for managing WA’s parks, forests and reserves. Planned activities do not impact DBCA’s functions, interests or activities.

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Stakeholder	Relevant to activity	Reasoning
Department of Mines, Industry Regulation and Safety (DMIRS)	Yes	Required to be consulted under the Regulations.
Department of Primary Industries and Regional Development (DPIRD)	Yes	Responsible for managing State fisheries.
Department of Transport (DoT)	Yes	Legislated responsibility for oil pollution response in State Waters.
Commonwealth fisheries*		
Southern Bluefin Tuna Fishery	No	Fishery overlaps the Operational Area, but there has been no recent fishing effort in the area.
Western Skipjack Fishery	No	Fishery overlaps the Operational Area, but there has been no recent fishing effort in the area.
Western Tuna and Billfish Fishery	Yes	Fishery overlaps the Operational Area, and there is potential for interaction with this fishery's licence holders.
State fisheries*		
Mackerel Managed Fishery – Pilbara (Area 2)	Yes	Fishery overlaps the Operational Area and there has been recent fishing effort.
Marine Aquarium Managed Fishery	No	Fishery overlaps the Operational Area, but typical water depth for fishing is not relevant to the area.
Onslow Prawn Managed Fishery	No	Fishery overlaps the Operational Area, but typical water depth for fishing is not relevant to the area.
Pearl Oyster Managed Fishery	No	Zone 1 of the fishery overlaps the Operational Area, but water depth for diver-based fishing is not relevant to the area.
Pilbara Demersal Scalefish Fisheries		
• Pilbara Trawl Fishery	Yes	Fishery overlaps the Operational Area and there has been recent fishing effort.
• Pilbara Trap Fishery	Yes	Fishery overlaps the Operational Area and there has been recent fishing effort.
• Pilbara Line Fishery	Yes	Fishery overlaps the Operational Area and there has been recent fishing effort.
South West Coast Salmon Managed Fishery	No	Fishery overlaps the Operational Area, but there has been no recent fishing effort in the area.
Specimen Shell Managed Fishery	No	Fishery overlaps the Operational Area, but shell collection method and typical water depth for collection is not relevant to the area.

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Stakeholder	Relevant to activity	Reasoning
West Australian Abalone Fishery	No	Fishery overlaps the Operational Area, but typical water depth for fishing is not relevant to the area.
West Coast Deep Sea Crustacean Managed Fishery	No	Fishery overlaps the Operational Area, but there has been no recent fishing effort in the area.
Industry		
BP Developments	Yes	Adjacent Titleholder
Mobil Australia	Yes	Adjacent Titleholder
Santos	Yes	Adjacent Titleholder
Sapura Exploration and Petroleum	Yes	Adjacent Titleholder
Industry representative organisations		
Australian Petroleum Production and Exploration Association (APPEA)	Yes	Represents the interests of oil and gas explorers and producers in Australia.
Commonwealth Fisheries Association (CFA)	Yes	Represents the interests of commercial fishers with licences in Commonwealth Waters. Activities are unlikely to impact commercial fishers.
Pearl Producers Association (PPA)	Yes	Although interactions with licence holders in the Pearl Oyster Managed Fishery are unlikely, PPA has requested to be informed of Woodside's planned activities.
Recfishwest	No	Represents the interests of recreational fishers in Western Australia. Activities are unlikely to impact recreational fishers given the distance from shore.
Western Australian Fishing Industry Council (WAFIC)	Yes	Represents the interests of commercial fishers with licences in State Waters. There is potential for interaction with commercial fishers in these State fisheries: • Pilbara Trawl Fishery • Pilbara Trap Fishery • Pilbara Line Fishery • Mackerel Fishery
Other Stakeholders		
Charter boat operators	No	There has been no recent fishing effort in the Operational Area by charter boat operators.

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** Fisheries have been identified as being relevant on the basis of fishing licence overlap with the proposed Operational Area, as well as consideration of fishing effort data, fishing methods and water depth. Table 4-8 provides a detailed assessment of Commonwealth and State fisheries within or adjacent to the Operational Area.*

5.5 Stakeholder Consultation Plan

Consultation activities undertaken for the proposed activity are outlined in Table 5-2**.**

In addition, Woodside published a consultation Information Sheet at www.woodside.com.au/sustainability/transparency/consultation-activities and provided a toll-free 1800 phone number to support consultation activities.

Table 5-2: Stakeholder consultation activities

Stakeholder	Date	Consultation activities
Commonwealth Government department or agency		
ACS	8 July 2019	Email advising of proposed activity and consultation Information Sheet.
AFMA	28 August 2019	Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries map relevant to proposed activity.
AHS	8 July 2019	Email advising of proposed activity, consultation Information Sheet and shipping lane map relevant to proposed activity.
AMSA (maritime safety)	8 July 2019	Email advising of proposed activity, consultation Information Sheet and shipping lane map relevant to proposed activity.
AMSA (marine pollution)	27 August 2019	Email advising of proposed activity and provide copy of the Oil Pollution First Strike Plan
DAWR	2 August 2019	Email and Information Sheet provided advising of proposed activity. Advice provided that no expected impacts from planned activities to Commonwealth fisheries. Information provided in line with DAWR consultation expectations on prevention of the introduction of IMS.
DIIS	8 July 2019	Email advising of proposed activity and consultation Information Sheet.
WA Government department or agency		
DMIRS	8 July 2019	Email advising of proposed activity and consultation Information Sheet.
DPIRD	8 July 2019	Email advising of proposed activity, consultation Information Sheet and State fisheries map relevant to proposed activity. Offer to meet in person.
	10 July 2019	Follow-up phone call up with DPIRD.

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Stakeholder	Date	Consultation activities
	15 August 2019	Follow-up email of proposed activity, consultation Information Sheet and State fisheries map relevant to proposed activity. Offer to meet in person.
DoT	8 July 2019	Email advising of proposed activity and commitment for further consultation once oil spill planning for this activity is finalised.
	27 August 2019	Email advising of proposed activity and provide copy of the Oil Pollution First Strike Plan (Appendix H)
Commonwealth fisheries*		
Western Tuna and Billfish Fishery	28 August 2019	Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries map relevant to proposed activity.
State fisheries*		
Mackerel Managed Fishery – Pilbara (Area 2)	8 July 2019	Email/letter to licence holders providing information on potential impacts to fishers and Woodside's proposed management and mitigation measures, a consultation Information Sheet and State fisheries map relevant to proposed activity.
Pilbara Demersal Scalefish Managed Fisheries • Pilbara Trawl Fishery • Pilbara Trap Fishery • Pilbara Line Fishery	8 July 2019	Email/letter to licence holders providing information on potential impacts to fishers and Woodside's proposed management and mitigation measures, a consultation Information Sheet and State fisheries map relevant to proposed activity.
Industry		
BP Developments	8 July 2019	Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
Mobil Australia	8 July 2019	Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
Santos	8 July 2019	Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
Sapura Exploration and Petroleum	8 July 2019	Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
Industry representative organisations		
APPEA	8 July 2019	Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
CFA	28 August 2019	Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries map relevant to proposed activity.

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Stakeholder	Date	Consultation activities
PPA	8 July 2019	Email advising of proposed activity including potential impacts to commercial fishers and proposed management/mitigation measures, consultation Information Sheet and State fisheries map relevant to proposed activity.
WAFIC	8 July 2019	Email advising of proposed activity including potential impacts to commercial fishers and proposed management/mitigation measures, consultation Information Sheet and State fisheries map relevant to proposed activity.

Copies of communications material outlined in Table 5-2 is included in Appendix F.

5.6 Consultation Feedback

A summary of stakeholder feedback and Woodside's responses is outlined in Table 5-3**.**

Table 5-3: Assessment stakeholder consultation feedback

Stakeholder	Stakeholder feedback	Woodside response
Commonwealth Government department or agency		
ACS	No feedback received.	Woodside has addressed maritime security-related issues in Section 6 of this EP based on previous offshore activities. Woodside considers the level of consultation to be adequate.
AFMA	No feedback received.	Consultation Information Sheet, and fisheries map provided. Woodside considers the level of consultation to be adequate.
AHO	No feedback received.	Woodside will notify the AHO no less than four working weeks before operations commence. Woodside considers the level of consultation to be adequate.
AMSA	On 8 July 2019 AMSA emailed Woodside requesting the Master to email AMSA's Joint Rescue Coordination Centre at least 24–48 hours before operations commence and provided details of information required by the Centre in that communication. AMSA requested that the AHS be contacted through datacentre@hydro.gov.au no less than four working weeks before operations commence for the promulgation of related notices to mariners.	On 15 August 2019 Woodside emailed AMSA and confirmed that it will notify AMSA's Joint Rescue Coordination Centre at least 24–48 hours before operations commence. Woodside advised it will notify the AHO no less than four working weeks before operations commence.

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Stakeholder	Stakeholder feedback	Woodside response
	AMSA provided advice on obtaining vessel traffic plots, including digital data sets and maps.	Woodside noted AMSA's advice on vessel traffic information.
	On 21 August 2019 AMSA emailed Woodside acknowledging receipt of Woodside's advice and that a case number had been allocated.	On 23 August 2019 Woodside emailed AMSA clarifying whether its email was correct in response to advice about the Okha Operations EP. No further advice has been received from AMSA. Woodside considers the level of consultation to be adequate.
DAWR	No feedback received.	Woodside engaged relevant Commonwealth fishery licence holders, as well as their representative organisation. Woodside has addressed maritime biosecurity and commonwealth fishing related issues in Section 6 of this EP based on previous offshore activities. Woodside considers the level of consultation to be adequate.
DIIS	No feedback received.	Woodside engaged DIIS as is required under the Regulations. Assessment of this EP will be conducted by NOPSEMA as the offshore regulator. Woodside considers the level of consultation to be adequate.
WA Government department or agency		
DMIRS	On 19 July 2019 DMIRS emailed Woodside noting the activity advice and that no further information was required.	Woodside notes DMIRS' feedback.
DPIRD	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided to DPIRD. Follow-up phone call on 10 July 2019 and follow-up email sent on 15 August 2019. Woodside considers the level of consultation to be adequate.
DoT	On 17 July 2019 requested to be advised in accordance with its Guidance Note on oil pollution if there were any changes to Oil Spill Contingency Plans/OPEPs or change to spill risk.	Woodside committed to providing information to DoT if there were any changes to Oil Spill Contingency Plans/OPEPs or change to spill risk.
Commonwealth fisheries		

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Stakeholder	Stakeholder feedback	Woodside response
Western Tuna and Billfish Fishery Licence Holders	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
State fisheries		
Mackerel Managed Fishery – Pilbara (Area 2) Licence Holders	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
Pilbara Demersal Scalefish Managed Fisheries Licence Holders: • Pilbara Trawl Fishery	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
• Pilbara Trap Fishery	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
• Pilbara Line Fishery	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
Industry		
BP Developments	No feedback received.	Consultation Information Sheet and bespoke maps provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Mobil Australia	No feedback received.	Consultation Information Sheet and bespoke maps provided.

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Stakeholder	Stakeholder feedback	Woodside response
		Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Santos	No feedback received.	Consultation Information Sheet and bespoke maps provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Sapura Exploration and Petroleum	No feedback received.	Consultation Information Sheet and bespoke maps provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Industry representative organisations		
APPEA	No feedback received.	Consultation Information Sheet including map provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
CFA	No feedback received.	Consultation Information Sheet and Commonwealth fisheries map provided. Woodside considers the level of consultation to be adequate.
PPA	No feedback received.	Consultation Information Sheet, map and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Woodside considers the level of consultation to be adequate.
WAFIC	On 22 July WAFIC emailed Woodside noting that it would assess Woodside's advice under arrangements prior to WAFIC advice on 11 July 2019 that advice would be provided on a fee-for-service basis. WAFIC requested that proposed stakeholder information was sent to WAFIC prior to consultation with commercial fishers.	On 16 August 2019 Woodside responded to WAFIC. Woodside notes WAFIC's request.
	WAFIC requested that Woodside's Pilbara Line fishery map be amended to be clear that the fishery was open and active.	Woodside notes WAFIC's advice and will update maps for future consultation activities.
	WAFIC advised that Woodside should contact commercial fishers in Area 2 only of the Mackerel Managed Fishery.	Woodside advised it had obtained contact details for licence holders for Areas 1, 2 and 3 and will consult licence holders from relevant areas for future consultation activities.
	WAFIC requested greater clarity on exclusion zones, specifically:	Woodside confirmed:

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Stakeholder	Stakeholder feedback	Woodside response
	• Confirmation that all exclusion zones were pre-existing. • Advice on start and finish dates if exclusion zones were temporary. • Confirmation on the meaning of the term 'Operational Area' in Woodside's consultation materials. • Confirmation that the 'petroleum safety zone' was pre-existing.	• All exclusion zones were pre-existing • There were no temporary exclusion zones but Woodside would advise timing if needed for future petroleum activities • There was a 1500 m Operational Area around the Okha facility and subsea infrastructure, including wells and flowlines and the gas export line, which fishers can access • The 500 m PSZ was pre-existing
	WAFIC noted Woodside's use of DP vessels and seabed benefits but requested further information on seabed disturbances and underwater noise, specifically impacts of noise from DP vessels on fish hearing, feeding, spawning, behaviours and dispersal. WAFIC claimed that increase in noise was a significant issue in the Great Australian Bight for the proposed Stromlo exploration drilling program.	Woodside provided references of scientific research on the potential impacts to fish from continuous noise sources, as well as estimated source levels from the Okha facility and DP vessels. It was not expected that demersal fish communities would be exposed to noise levels from the Okha or DP vessels that would cause a recoverable injury or a temporary threshold shift in hearing. Woodside advised that there was no quantitative threshold for the potential behavioural effects of fish to underwater sound sources such as DP or vessel noise. It also advised that for the most sensitive fish type expected to be moderate within a range of hundreds of metres from the source. Mortality or injury to eggs and larvae from continuous sound sources was assessed as being 'low', regardless of the proximity to the source
	WAFIC requested additional information hydrocarbon release, specifically: • Advice if blowout preventers (BOPs) were in stock and on site? If not, the time it would it take to transport a BOP to site. • Advice on next options, such as capping stacks, if the use of BOPs were unsuccessful and the time it would it take to transport a capping stack to site. • Advice on planning and mobilisation of a standby rig if the above management measures were unsuccessful.	Woodside advised that its primary source control option for an unplanned hydrocarbon release for the Okha wells was ROV intervention followed by relief well drilling and/or subsea dispersant injection. Woodside advised that deployment of BOP stacks would not be considered as they can only be deployed using drilling rigs, which would not be allowed within an hydrocarbon release exclusion zone due to safety risk to personnel on the rig. Woodside advised that it is a signatory to a Memorandum of Understanding (MOU) between Australian offshore operators

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Stakeholder	Stakeholder feedback	Woodside response
	WAFIC also sought Woodside's position on the establishment of a standby rig in a convenient /readily accessible location in the event of an emergency.	to provide mutual aid to facilitate and expedite mobilising a mobile offshore drilling unit for drilling a relief well if an unplanned hydrocarbon release were to occur. The MOU commits the signatories to share rigs, equipment, personnel and services to assist another operator if required. Woodside considers this an appropriate approach to access a drilling unit if required. The timeframe for relief well drilling is being evaluated as part of Woodside's oil spill planning and response mitigation assessment process.
	WAFIC expressed its expectation of the following items for support vessels and requested Woodside to include these in the EP: • Diversion around commercial fishing vessels and remaining clear of fishing gear. • Avoidance of close and/or disruptive engagement with any commercial fishing activity. • Avoid activities that would cause disruption to schooling fish.	Woodside advised that all vessels on charter to Woodside comply with the International Rules for the Prevention of Collision at Sea. In observance of good seamanship all support vessels will avoid any close and or disruptive engagement with any commercial fishing activity. Woodside advised that this statement will be incorporated into the EP.
	WAFIC sought details on workforce, contractor and subcontractor communications and requested Woodside to include these in the EP, specifically: • Policy/processes regarding interacting and protecting the rights of active commercial fishers on the water. • Communication of EP processes across the workforce and how they are reviewed / audited.	Woodside advised that it provides campaign-specific EP inductions with each vessel chartered to ensure awareness of the key EP commitments. Woodside also maintains signed records of vessel crew contractors' participation in vessel marine inductions to ensure that all vessel crew are aware of Woodside's key commitments in the EP. Woodside's also has charterers instructions that describe the Master's obligation to comply with all EP requirements, including campaign environmental compliance. Woodside advised that this statement will be incorporated into the EP.
	WAFIC sought details on recreational fishing from support/commercial vessels and requested Woodside to include these in the EP, specifically: • Confirmation from Woodside of a 'no fishing from support/commercial vessel' and that this policy would be enforced and communicated with contractors and subcontractors • Woodside's audit / compliance policy / process regarding recreational fishing on support/commercial vessels.	Woodside advised that it prohibits recreational fishing activities at Woodside terminals and supply bases or within a 500 m zone of a Woodside-operated facility. It also advised that contractors and subcontractors implement their own policies regarding recreational fishing from their vessels, some of which include a total ban.

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Stakeholder	Stakeholder feedback	Woodside response
	WAFIC sought details on post-spill activities, specifically: • Processes to quantitively assess any damage to fish and shellfish stocks. • Plans for bespoke stock assessments to develop baseline understanding of the NWS area. • Details of scientific studies to understand stock baseline data in the event of a spill. • Details of scientific studies to understand spawning baseline data in the event of a spill. • Details of baseline data to inform potential financial compensation in the event of a spill.	Woodside provided details of its scientific monitoring program (SMP), which would be implemented in the event of a Level 2 or 3 unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors is activated. The objectives of the SMP are to: • Assess the extent, severity and persistence of the environmental impacts from the spill event • Monitor subsequent recovery of impacted key species, habitats and ecosystems. The SMP comprises environmental monitoring programs for a range of physical-chemical (water and sediment) and biological (species and habitats) receptors. Woodside advised that in the event of a spill it would support the WA Government to assess contamination of any caught finfish and/or shellfish to assess fitness for consumption. Woodside also provided advice on the assessment on fish populations in the event of a spill, acknowledging challenges given the considerable natural fluctuations in population dynamics in the offshore environment. Woodside advised it would consider implications for fishers in the unlikely event of a hydrocarbon spill on a case-by-case basis.
	WAFIC sought details on Woodside's learning and understanding of global oil spill events to inform planning for activities undertaken under the Okha EP given the isolated location of the facilities, specifically: • Lessons learned from global spill events, especially in relation to emergency response preparedness and early control of oil loss. • Expectations for the time for a rig to arrive at the location. WAFIC claimed that a standby / back-up rig should be anchored at a 'best possible' location in Australia or in WA's case, possibly in Asian waters, adding that a long delay between a major spill event and the arrival of a backup rig is an unacceptable risk level that does not meet ALARP assessment.	Woodside advised it was continually learning and updating its hydrocarbon spill process to ensure planning is commensurate to the risk and aligns with operator experience globally. This includes alignment with guidance provided by NOPSEMA, regular discussion with other oil and gas operators, lessons learnt from NOPSEMA inspections and engagement with oil spill response organisations. Woodside confirmed it was still evaluating source control, well intervention and the relief well rig response activities in line with corporate source control procedures and the latest Industry Source Control Emergency Response Planning Guide for Subsea Wells, released by the International

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Stakeholder	Stakeholder feedback	Woodside response
	• Woodside's position on the permanent siting of a standby / backup rig at a suitable location in Australia for oil and gas industry use in the event of a major spill event. • Woodside's position on industry support and funding for a standby / backup rig being permanently parked in Australia to ensure a rapid response time in the event of an emergency. • Woodside's position on a more rapid response if a standby / backup rig was not permanently parked in Australia, including the development of a defined relationship with a backup rig located, for example, somewhere in Asia.	Association of Oil and Gas Producers and the International Petroleum Industry Environmental Conservation Association, January 2019 (Report 594). This included evaluating feasibility, effectiveness, cost and environmental benefit and timeframes for response activities. Woodside advised that the EP for this activity demonstrated that the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, were controlled to ALARP levels. Woodside's oil spill response plan (first strike plan; Appendix H) set out options for responding to a loss of well integrity in line with industry best practice, including measures that would be taken prior to relief well drilling and subject to risk assessment and approvals. This was supported by the MOU with other Australian offshore operators to share rigs, equipment, personnel and services if required.
	WAFIC sought confirmation from Woodside on the respective sections of the EP that matters raised by WAFIC would be included.	Woodside advised it would provide WAFIC with the locations of where matters raised above would be included within the EP.

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5.7 Ongoing Stakeholder Consultation

Woodside is committed to the engagements listed in Table 5-4, based on stakeholder feedback.

Table 5-4: Assessment ongoing stakeholder consultation

Stakeholder	Activity
AMSA	Woodside will notify AMSA's Joint Rescue Coordination Centre at least 24–48 hours before operations commence for each survey.
	Woodside will notify the AHO no less than four working weeks before operations commence.

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6. ENVIRONMENTAL IMPACT AND RISK ASSESSMENT, PERFORMANCE OUTCOMES, STANDARD AND MEASUREMENT CRITERIA

6.1 Overview

This section presents the impact and risk analysis and evaluation, EPOs, EPSs and MC for the Petroleum Activities Program, using the methodology described in Section 2.

6.2 Analysis and Evaluation

As required by Regulation 13(5) and 13(6) of the Environment Regulations, the analysis and evaluation demonstrate that the identified risks and impacts associated with the Petroleum Activities Program are reduced to ALARP, are of an acceptable level and consider all operations of the activity, including potential emergency conditions.

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

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

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

The ENVID identified 8 impacts and 12 risks associated with the Petroleum Activities Program. Planned activities and unplanned events are summarised in Table 6-1 and Table 6-2.

The analysis and evaluation for the Petroleum Activities Program indicate that all the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level, as discussed further in Sections 6.6, 6.6.8, and 6.8.

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Table 6-1: Environmental impact analysis summary of planned activities

Aspect	EP Section	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Controlled Impact Classification	Residual Impact Level (ALARP controls in place)	Acceptability of Impact
Planned Activities (Routine and Non-routine)						
Physical presence: Disturbance to marine users	6.6.1	Presence of Okha FPSO and subsea infrastructure excluding and/or displacing other users from PSZ and Operational Area respectively.	Isolated social impact potentially resulting from interference with other sea users (e.g. commercial and recreational fishing, and shipping).	F	Social & Cultural – No lasting effect (<1 month). Localised impact not significant to area/item of cultural significance.	Broadly Acceptable
Physical presence: Disturbance to seabed	6.6.2	Presence of subsea infrastructure (including moorings) modifying marine habitats.	Localised modification of seabed habitat (formation of artificial reef) within Operational Area.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed	Slight, short-term modification of seabed habitat within Operational Area with slight short-term impacts to water quality and benthic communities.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly Acceptable
Routine acoustic emissions: Generation of noise during routine operations	6.6.3	Noise generated within the Operational Area from: • Okha FPSO and associated infrastructure • vessels and IMMR activities • helicopters.	Localised behavioural impacts to marine fauna around and within the Operational Area with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
Routine and non-routine discharges: Discharge of hydrocarbons and chemicals during subsea operations and activities	6.6.4	Discharge of subsea control fluids.	Slight, short-term impacts to water quality and benthic communities within Operational Area.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly Acceptable
		Discharge of hydrocarbons remaining in subsea pipework and equipment as a result of subsea intervention works.	Slight, short-term decrease in water quality at release location during IMMR activities.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly Acceptable
		Discharge of chemicals remaining in subsea pipework and equipment, or the use of chemicals for subsea IMMR activities.	Localised decrease in water quality at release location during IMMR activities with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Discharge of minor fugitive hydrocarbon/chemicals from wells and subsea equipment.	Localised decrease in water quality around subsea system within Operational Area with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
Routine and non-routine discharges: Produced water	6.6.5	Discharge of PW from FPSO.	Slight short-term, localised decrease in water quality, marine sediments and marine biota.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	Broadly Acceptable
Routine and non-routine discharges: Discharges from utility systems and drains	6.6.6	Discharge of sewage, greywater and putrescible waste from FPSO and vessels to the marine environment.	Localised decrease in water quality (increased nutrients and biological oxygen demand) with no lasting effect.	F Cumulative E	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Discharge of deck water from FPSO and bilge water from vessels to the marine environment.	Localised decrease in water quality at the discharge location with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Discharge of brine from vessels and FPSO to the marine environment.	Localised decrease in water quality at the discharge location with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Discharge of seawater systems (including cooling water) from FPSO and vessels to the marine environment.	Localised increase in salinity at the discharge location with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
Routine and non-routine atmospheric emissions: Fuel combustion, flaring and fugitives	6.6.8	FPSO and vessel fuel combustion emissions, FPSO operational flaring and fugitive emissions	Localised decrease in air quality, limited to the airshed local to the facility with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable

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Aspect	EP Section	Source of Impact	Key Potential Environmental Impacts (Refer to relevant EP section for details)	Controlled Impact Classification	Residual Impact Level (ALARP controls in place)	Acceptability of Impact
Routine light emissions: Light emissions from FPSO and vessels	6.6.8	Light emissions from FPSO and vessels.	Localised behavioural disturbance of species in close proximity to FPSO and vessels with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable
		Light emissions from FPSO during flaring.	Localised behavioural disturbance of species in close proximity to FPSO with no lasting effect.	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	Broadly Acceptable

Table 6-2: Environmental risk analysis summary of unplanned events (including MEEs)

Aspect	EP Section	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP Section for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Risk Rating	
Unplanned Events (Accidents/Incidents)								
Unplanned hydrocarbon or chemical release: Hydrocarbon release during bunkering/refuelling and chemical transfer, storage and use	6.7.1	Accidental spill of hydrocarbons to the environment during bunkering/refuelling.	Potential minor short-term impacts to the marine environment, including decrease in water quality and minor impacts to marine biota.	D	Environment – Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	2	M	Broadly acceptable
		Accidental discharge of chemicals to the marine environment from storage, use or transfer.	Potential slight, short-term impact to the marine environment, including the potential for slight impacts to marine biota.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	4	M	Broadly acceptable
Unplanned discharges: Waste management	6.7.2	Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.	Potential for isolated, slight, short-term impacts to marine biota with no lasting effect.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	2	M	Broadly acceptable
Physical presence: Vessel interaction with marine fauna	6.7.3	Physical presence of vessels resulting in collision with marine fauna.	Potential injury or death of marine fauna (single animal), including protected species. No lasting effect to populations.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Physical presence: Introduction of IMS	6.7.4	Invasive species in vessel ballast tanks or on vessels/ submersible equipment.	Potential for minor impact to marine ecosystems.	E	Environment – Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystem function), physical or biological attributes.	1	L	Broadly acceptable
Unplanned Events (Accidents/Incidents) – MEEs								
Unplanned hydrocarbon release: Loss of well containment (MEE-01)	6.8.3	Release of hydrocarbons resulting from loss of subsea well containment.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	0	M	Acceptable if ALARP

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Aspect	EP Section	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP Section for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Risk Rating	
Unplanned hydrocarbon release: Subsea equipment loss of containment (MEE-02) [5]	6.8.4	Release of hydrocarbons resulting from subsea equipment loss of containment.	Potential significant impacts to the marine environment. Disruption to marine fauna, including protected species. Potential long-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	2	M	Acceptable if ALARP
Unplanned hydrocarbon release: Topsides loss of containment (MEE-03)[6]	6.8.5	Hydrocarbon release from topsides process equipment to the marine environment and atmosphere.	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	D	Environment – Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	1	M	Acceptable if ALARP
		Hydrocarbon release from topsides non-process equipment to the marine environment.	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	D	Environment – Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: Offtake equipment loss of containment (MEE-04)[5]	6.8.6	Hydrocarbon release from Okha FPSO offtake equipment to the marine environment and atmosphere.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
Unplanned hydrocarbon release: Cargo tank loss of containment (MEE-05)	6.8.7	Hydrocarbon release caused by a cargo tank loss of containment.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: Loss of structural integrity (MEE-06)	6.8.8	Hydrocarbon release caused by a loss of structural integrity, leading to: • MEE-02 – Subsea flowline and riser loss of containment • MEE-03 – Topsides loss of containment • MEE-04 – Offtake equipment loss of containment • MEE-05 –FPSO Cargo tank loss of containment. Cargo tank loss of containment selected as bounding case.	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP
Unplanned hydrocarbon release: Loss of marine vessel separation (MEE-07)	6.8.9	Hydrocarbon release caused by a loss of marine vessel separation, leading to: • MEE-02 – Subsea flowline and riser loss of containment • MEE-03 – Topsides loss of containment • MEE-04 – Offtake equipment loss of containment	Potential significant impacts to the marine environment. Long-term impacts to sensitive nearshore areas of offshore islands and coastal shorelines. Disruption to marine fauna, including protected species. Potential medium-term interference with or displacement of other sea users.	A	Environment – Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitats or physical or biological attributes.	1	H	Acceptable if ALARP

[5] MEE based on reputational risk
[6] Whilst environment consequence does not meet definition as standalone MEE, scenario and bowtie assessment have been retained as a means of articulating causes and ALARP controls to prevent escalation to other MEEs

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Aspect	EP Section	Source of Risk	Key Potential Environmental Impacts (Refer to relevant EP Section for details)	Risk Rating				Acceptability of Risk
				Consequence Classification	Potential Consequence/Level of Impact	Likelihood	Risk Rating	
		• MEE-05 – Okha FPSO Cargo tank loss of containment.						
Unplanned hydrocarbon release: Loss of control of suspended load from facility lifting operations (MEE-08)	6.8.10	Hydrocarbon release from subsea equipment to the marine environment and atmosphere (MEE-02).	Potential significant impacts to the marine environment. Disruption to marine fauna, including protected species. Potential long-term interference with or displacement of other sea users.	C	Environment – Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	1	M	Acceptable if ALARP
		Hydrocarbon release from topsides equipment to the marine environment and atmosphere (MEE-03).	Potential significant impacts to the marine environment, including disruption to marine fauna (including protected species), and potential short-term interference with or displacement of other sea users.	D	Environment – Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems), physical or biological attributes.	1	M	Acceptable if ALARP

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6.2.1 Cumulative Impacts

Woodside has assessed the cumulative impacts of the Petroleum Activities Program in relation to other relevant petroleum activities that could realistically result in overlapping temporal and spatial extents. Other facilities located close to the Operational Area include NRC, Angel and GWA (distances to these facilities are outlined in Section 4.6.7). However, given environmental risks and impacts from the Petroleum Activities Program are concentrated around the Okha FPSO, the potential for cumulative impacts is considered to be low. Cumulative impacts are discussed for sources of risk and impacts where such impacts were deemed to be credible.

6.3 Environmental Performance Outcomes, Standards and Measurement Criteria

Regulation 13(7) of the Environment Regulations requires that an EP includes EPOs, EPSs and MC that address legislative and other controls to manage the environmental risks and impacts of the activity to ALARP and Acceptable levels.

EPOs, EPSs and MC for the Petroleum Activities Program have been identified to allow Woodside's environmental performance to be measured and through the implementation of this EP, to determine whether the EPOs and EPSs have been met.

The EPOs, EPSs and MC specified are consistent with legislative requirements and Woodside's standards and procedures. They have been developed based on the legislation, codes and standards, good industry practices and professional judgement outlined in Sections 2.6.1.4 and 2.8, as part of the acceptability and ALARP justification process.

The EPOs, EPSs and MC are presented throughout this section and in Appendix D. A breach of these EPOs or EPSs constitutes a 'Recordable Incident' under the Environment Regulations (refer to Section 7.7.5).

6.4 Presentation

The analysis and evaluation (ALARP and acceptability), EPOs, EPSs and MC are presented in tabular form throughout this section, as shown in the sample below. Italicised text in this example table denotes the purpose of each part of the table, with reference to the relevant sections of the Regulations and/or this EP.

<table>
<tr><th colspan="15">Context
Description of the context for the impact/risk. Regulation 13(1, 13(2) and 13(3)</th></tr>
<tr><td>Description of the Activity – Regulation 13(1)</td><td colspan="6">Description of the Environment – Regulations 13(2)(3)</td><td colspan="8">Consultation – Regulation 11A</td></tr>
<tr><th colspan="15">Impacts and Risks Evaluation Summary
Summary of ENVID outcomes</th></tr>
<tr><td rowspan="2">Source of Risk
Regulation 13(1)</td><td colspan="7">Environmental Value Potentially Impacted
Regulations 13(2)(3)</td><td colspan="7">Evaluation
Section 2</td></tr>
<tr><td>Soil and Groundwater</td><td>Marine Sediment</td><td>Water Quality</td><td>Air Quality (incl Odour)</td><td>Ecosystems/ Habitat</td><td>Species</td><td>Socioeconomic</td><td>Decision Type</td><td>Consequence/Impact</td><td>Likelihood</td><td>Risk Rating</td><td>ALARP Tools</td><td>Acceptability</td><td>Outcome</td></tr>
<tr><td>Summary of source of risk/ impact</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

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Description of Source of Risk or Impact
Description of the identified risk/impact including sources or threats that may lead to the impact/risk or identified event. Regulation 13(1).
Impact or Consequence Assessment
Environmental Value/s Potentially Impacted
Discussion and assessment of the potential impacts to the identified environment value/s. Regulation 13(5) (6). Description of potential impacts to environmental values aligned to Woodside Risk Matrix consequence descriptors.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[7]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
ALARP/Hierarchy of Control Tools Used - Section 2.6.2				
Summary of control considered to ensure the impacts and risks are continuously reduced to ALARP. *Regulation 13(5)(c).*	*Technical/logistical feasibility of the control.* *Cost/sacrifice required to implement the control (qualitative measure).*	*Qualitative commentary of impact/risk that could be averted/ environmental benefit gained if the cost/ sacrifice is made and the control is adopted.*	*Proportionality of cost/sacrifice vs environmental benefit. If proportionate (benefits outweigh costs), the control will be adopted. If disproportionate (costs outweigh benefits), the control will not be adopted.*	*If control is adopted, reference to Control No. provided.*
Major Environment Events MEEs are subject to additional analysis and evaluation as outlined in Sections 2.7 and 6.8.2. ALARP is demonstrated through controls being analysed for selection, based on their independence, and prioritised in accordance with hierarchy of controls, and further analysed to consider the type of effect the control provides.				
ALARP Statement Made on the basis of the environmental risk/impact assessment outcomes, use of the relevant tools appropriate to the decision type (Section 2.8 and Figure 2-8) and a proportionality assessment. Regulation 10A (b).				

Demonstration of Acceptability
Acceptability Statement Made on the basis of applying the process described in Section 2.8 and Figure 2-8 taking into account internal and external expectations, risk/impact to environmental thresholds and use of environment decision principles. Regulation 10A(c)

EPOs, EPSs and MC			
Environmental Performance Outcomes	***Controls***	***Environmental Performance Standards***	***Measurement Criteria***
EPO No. **S**: *Specific performance that addresses the legislative and other controls that manage the activity, and against which performance*	**C No.** *Identified control adopted to ensure that the impacts and*	**PS No.** *Statement of the performance required of a control measure. Regulation 13(7)(a).*	**MC No.** *Measurement criteria for determining whether the outcomes and*

[7] Qualitative measure

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EPOs, EPSs and MC			
Environmental Performance Outcomes	***Controls***	***Environmental Performance Standards***	***Measurement Criteria***
by Woodside in protecting the environment will be measured. **M***: Performance against the outcome will be measured through implementation of the controls via the MC.* **A***: Achievability/feasibility of the outcome demonstrated via discussion of feasibility of controls in ALARP demonstration. Controls are directly linked to the outcome.* **R***: The outcome will be relevant to the source of risk/impact and the potentially impacted environmental value*[8] **T***: The outcome will state the timeframe during which the outcome will apply or by which it will be achieved.*	*risks are continuously reduced to ALARP.* *Regulation 13(5) (c).*		*standards have been met.* *Regulation 13(7)(c).*

6.5 Environment Risks/Impacts not Deemed Credible

The ENVID identified a source of environmental risk/impact that was assessed as not being applicable (not credible) within or outside the Operational Area and therefore was determined to not form part of this EP (refer Section 2.5). This is described in Section 6.5.1 for information only.

6.5.1 Shallow/Nearshore Activities

The Petroleum Activities Program is in water depths between ~75 m and 130 m, and at a distance of ~119 km from nearest landfall (Dampier). Consequently, risks/impacts associated with shallow/nearshore activities—such as anchoring and vessel grounding—were assessed as not credible.

[8] Where impact/consequence descriptors are capitalised and presented within EPOs in Section 6; performance level corresponds with those aligned with the Woodside Risk Matrix (refer Section 2).

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6.6 Planned Activities (Routine and Non-routine)

6.6.1 Physical Presence: Disturbance to Marine Users

Context		
Location – Section 3.2 Operational Area – Section 3.3 Facility Layout and Description – Section 3.5 Facility Operations – Section 3.6.9	Socioeconomic and Cultural – Section 4.6	Stakeholder Consultation – Section 5

Impact Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Presence of Okha FPSO and subsea infrastructure excluding and/or displacing other users from PSZ and Operational Area respectively.	-	-	-	-	-	-	X	A	F	-	-	LCS GP PJ	Broadly Acceptable	EPO 1

Description of Source of Impact

The Okha FPSO commenced production in September 2011. Prior to this, the reservoirs were produced through the Cossack Pioneer FPSO, which commenced production in 1995. The Okha FPSO has been marked on nautical charts since that time. The FPSO lies within a PSZ that comprises the area within a 500 m radius of the RTM. The 500 m PSZ is shown as a 'Restricted Area' on navigation charts. The PSZ excludes vessels except those under the control of the operator or excepted as described in Notice to Mariners: A525517.

The physical footprint of subsea infrastructure is highly localised and entirely contained within the Operational Area. The AHS has been notified of the location of subsea infrastructure for marking on nautical charts. Water depths of subsea infrastructure range between ~75 m and 130 m.

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

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Impact Assessment
Exclusion and Displacement of Other Users Commercial Fishing Management boundaries for several Commonwealth and State fisheries were identified as overlapping the Operational Area (Section 4.6.3). The likely presence of commercial fishing vessels was assessed based on fishing gear type, historical effort and feedback from consultation, with consideration of the duration that the facility has been in operation (Section 3.4). Commercial fishing vessels in the vicinity of the Operational Area are most likely to be participants of the Pilbara Demersal Scalefish Managed Fishery and Mackerel Managed Fishery and may use several gear types (including trawling). However, a portion of the Operational Area lies within Zone 2 Area 6 of the Pilbara Demersal Scalefish Managed Fishery, an area closed to trawling since 1997. From 2013 to 2018, three vessels have fished intermittently in areas that may overlap the Operational Area. Historical data has identified that most of this fishing effort has been part of the Pilbara Demersal Scalefish Managed Fishery, as there has been no fishing effort from the Mackerel Managed Fishery since 2016 in the Operational Area. In 2018, the Operational Area overlapped 4.8% of the area used by the Pilbara Demersal Scalefish Managed Fishery. Consultation with fishing industry participants did not indicate any claims or objections from commercial fishers to the Petroleum Activities Program (Section 5). The impact to commercial fishers as a result of the Petroleum Activities Program is considered to be a potential for highly localised displacement of effort with no lasting effect. As no trawling effort is expected to occur in the Operational Area, the potential for trawling gear to be snagged on subsea infrastructure is considered remote. No additional displacement or exclusion of commercial fisheries are expected in this revision of the EP. Tourism and Recreation Tourism and recreation activity in the Operational Area is expected to be infrequent. There are no emergent features or natural values within the Operational Area that are considered tourist attractions. Recreational and charter fishing from vessels are the only tourism and recreation activities identified that may potentially occur in the Operational Area. However, data indicates that there has been no catch effort from charter vessels in the Operational Area for the last five years (Section 4.6.5). Given the distance from shore and boating facilities, lack of natural attractions and water depth of the Operational Area, no recreational or charter fishing has previously occurred or is expected to occur in the future. As such, impacts to recreational and charter fishing (entanglement of equipment, displacement of fishers) are expected to be localised with no lasting effect. Shipping Considerable commercial shipping occurs in the region (Section 4.6.6), comprising vessels such as: • offtake tankers • bulk carriers (e.g. mineral ore, salt) from Port Hedland and Dampier • support vessels for offshore oil and gas activities • LNG carriers from Dampier, Barrow Island and Ashburton North. To reduce the likelihood of interactions between commercial vessels and offshore facilities, AMSA has introduced a series of shipping fairways, within which commercial vessels are advised to navigate. The fairways are not mandatory, but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region. The use of shipping fairways is considered to be good seafaring practice, with Australian Ship Reporting System data from AMSA indicating cargo ships and tankers routinely navigate within the established fairways. However, no recognised shipping lanes overlap the Operational Area; the nearest fairway lies ~35 km north-west of the Operational Area. The presence of the Okha FPSO, associated subsea infrastructure and support vessels will not result in impacts to commercial shipping beyond a localised exclusion of shipping traffic from the PSZ, and the temporary displacement of commercial shipping from subsea support vessels as a result of vessels undertaking activities in the Operational Area. This is considered a localised impact, and of no lasting effect. Oil and Gas The nearest oil and gas platform is the NRC facility. NRC is operated by Woodside; impacts from the Petroleum Activities Program to NRC will not affect third parties. The nearest non–Woodside-operated production facility is the Reindeer platform operated by Santos, which is ~45 km south of the Operational Area (51 km from the Okha FPSO). Given the distance between the Operational Area and petroleum activities undertaken by other operators, no impacts to other operators will occur as a result of the presence of FPSO, vessels or subsea infrastructure.

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[9]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Contract vessels compliant with Marine Orders for safe vessel operations: • Marine Order 21 (Safety and emergency arrangements) • Marine Order 30 (Prevention of Collisions). Compliance with Marine Orders 21 and 30 reduces the likelihood of interaction of vessel with the FPSO.	F: Yes CS: Minimal Cost. Standard practice.	Marine Orders 21 and 30 are required under Australian regulations; implementation is standard practice for commercial vessels as applicable to vessel size, type and class.	Control based on legislative requirement – must be adopted	Yes **C 1.1**
Implementation of a 500 m PSZ around the FPSO.	F: Yes CS: Minimal cost. Standard practice.	The PSZ is a requirement under the OPGGS Act.	Control based on legislative requirement – must be adopted.	Yes **C 1.2**
Good Practice				
Notifying AHS of location of permanent new Okha infrastructure to enable update of maritime charts, thereby reducing the likelihood of unplanned interactions with Okha infrastructure.	F: Yes: CS: Minimal cost. Standard practice	Notifying AHS will enable them to update maritime charts, thereby reducing the likelihood of unplanned interactions with Okha infrastructure.	Benefits outweigh the cost sacrifice	Yes **C 1.3**
Routinely consult stakeholders for the Petroleum Activities Program to ensure marine users are informed and aware, thereby reducing the likelihood of unplanned interactions with Okha infrastructure.	F: Yes: CS: Minimal cost. Standard practice	Routine consultation with marine users ensures they are informed and aware, thereby reducing the risk of unplanned interactions with Okha infrastructure	Benefits outweigh the cost sacrifice	Yes **C 1.4**
Professional Judgement – Eliminate				
Reduce the PSZ.	F: No. The PSZ is mandated by the OPGGS Act and is a safety and environment critical element; it cannot be reduced. CS: Not assessed, control not feasible.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Professional Judgement – Substitute				
None identified				

1 Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[9]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Professional Judgement – Engineered Solution				
Over-trawl protection on subsea infrastructure.	F: Yes. Over-trawl protection on subsea infrastructure could be fitted to Okha FPSO subsea infrastructure. CS: Significant additional cost associated with designing and installing trawl protection on subsea infrastructure.	Over-trawl protection on subsea infrastructure could mitigate the potential for commercial fishing trawl gear to damage infrastructure or result in gear loss.	Given the Operational Area overlaps a small proportion of the fisheries management area open to trawl fishing, the cost of installing over-trawl protection is considered grossly disproportionate to the social benefit	No

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of the physical presence of the Okha FPSO, subsea infrastructure and vessels on other users. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.

Demonstration of Acceptability

Acceptability Statement

The impact assessment has determined that, given the adopted controls, the ongoing physical presence of the Okha FPSO, subsea infrastructure and vessels represents a highly localised displacement to commercial fishing, shipping and other oil and gas titleholders with no lasting effect. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good practice and meet requirements of Marine Orders 21 and 30, and the expectations of WAFIC, AMSA and AHS provided during consultation with stakeholders. The potential impacts and risks are considered broadly acceptable, if the adopted controls continue to be implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts of the physical presence of the Okha FPSO and support vessels to a level that is broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 1 Prevent adverse interactions between vessels/FPSO and other marine users during the Petroleum Activities Program.	**C 1.1** Support vessels complying with Marine Orders for safe vessel operations: • Marine Order 21 (Safety of navigation and emergency procedures) • Marine Order 30 (Prevention of Collisions).	**PS 1.1** Vessels contracted whose practices comply with Marine Orders as applicable to vessel size, type and class (Marine Orders 21 and 30).	**MC 1.1.1** Marine verification records demonstrate compliance with standard maritime safety procedures (Marine Orders 21 and 30).
	C 1.2 Implementation of a 500 m PSZ around FPSO.	**PS 1.2** PSZ monitored for incursions.	**MC 1.2.1** Records of adverse interactions in 500 m PSZ with other marine users entered into First Priority.
	C 1.3 Notifying AHS of locations of new permanent infrastructure to enable AHS to update maritime charts.	**PS 1.3** Woodside to notify AHS of location of new permanent infrastructure.	**MC 1.3.1** Records demonstrate that AHS has been notified of new permanent infrastructure.
	C 1.4 Undertaking consultation program to advise relevant persons of the Petroleum Activities Program and provide opportunity to raise objections or claims.	**PS 1.4** Implement a consultation process that conforms to the requirements of the Environment Regulations.	**MC 1.4.1** Records demonstrate a consultation program that conforms to the requirements of the Environment Regulations has been undertaken (refer to Section 7).

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6.6.2 Physical Presence: Disturbance to Seabed

Context

Location – Section 3.2 Operational Area – Section 3.3 Facility Layout and Description – Section 3.5 Facility Operations – Section 3.6.9	Socioeconomic and Cultural – Section 4.6	Stakeholder Consultation – Section 5

Impact Evaluation Summary

	Environmental Value Potentially Impacted							***Evaluation***						
Source of Impact	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Presence of subsea infrastructure (including moorings) modifying marine habitats.	-	X	X	-	X	-	-	A	F	-	-	LCS GP PJ	Broadly Acceptable	EPO 2
Subsea operations, inspection, maintenance and repair activities resulting in disturbance to seabed	-	X-	X-	-	X-	-	-	A	E	-	-			

Description of Source of Impact

Seabed disturbance associated with the Petroleum Activities Program can occur during operations and IMMR activities. Subsea infrastructure has been installed throughout the Operational Area (Section 3.3). Subsea equipment has been installed historically, subject to separate EPs. Installation and historical operations have described the benthic footprint/disturbance. The physical footprint of existing subsea infrastructure is described in this section for completeness.

The FPSO and subsea infrastructure also provides hard substrate habitat from the sea surface through the water column to the seabed (i.e. RTM), as well as along the seabed (e.g. flowlines, manifolds).

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

Flowline movement may occur as per design and within integrity margins along flowline corridors.

To maintain the integrity of subsea infrastructure, routine subsea IMMR activities may be required, as described in Section 3.10. IMMR activities may impact the benthic environment near the activity. IMMR activities identified as impacting the benthic environment include (but are not limited to):

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

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- spool repair/replacement – minor, localised modification of benthic habitat near the spool.

The area of benthic habitat predicted to be impacted varies depending on the nature and scale of the IMMR activity.

Impact Assessment

The presence of subsea infrastructure and IMMR activities can be categorised into two potential impacts:

- direct physical disturbance of benthic habitat
- indirect disturbance to benthic habitats from sedimentation.

Water Quality

Indirect seabed disturbance may include localised and temporary decline in water quality due to increased suspended sediment concentrations and increased sediment deposition caused by IMMR activities and during disturbance to seabed from subsea infrastructure. However, sediment loads are not expected to be significant due to the relatively small footprint for each activity and event (described above, and in Section 3.10).

Benthic Communities/Habitats

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

IMMR activities such as span rectification, flowline protection and stabilisation will typically disturb a small area (typically <100 m^2) of soft sediment habitat. Scour and flowline movement may result in localised impacts to soft sediment habitats, typically on the scales of metres to tens of metres. Each discrete IMMR activity near the seabed is likely to cause a brief disturbance, which may result in suspended sediment. This sediment will subsequently be deposited down current as particles resettle. Such localised and short-term events may affect small areas of the seabed and consequently, impact the associated biota (typically sparsely distributed infauna and sessile epifauna). Given the expected nature and scale of resuspension resulting from these disturbances, impacts such as smothering or burial are not expected. Rather, impacts are likely to be restricted to increased ingestion of inedible sediments by filter feeders. Biota in the region are well adapted to periodic turbidity events caused by cyclones and tidal movements. As such, impacts from turbidity caused by these disturbances are not expected to have any lasting effect on benthic biota.

The estimated overall extent of such direct seabed disturbance is extremely small in relation to the extent of the soft sediment habitats, which are broadly represented within the Operational Area and the wider Northwest Province. Operational experience indicates disturbance to soft sediment habitats around subsea infrastructure associated with the Petroleum Activities Program is slight and short-term.

Artificial Habitats

Subsea infrastructure is often colonised by marine organisms; the availability of hard substrate is often a limiting factor in benthic communities. As such, the presence of infrastructure has led to the development of ecological communities that would not have existed otherwise (e.g. fouling communities on risers). For example, pipeline infrastructure has been shown to support demersal fish assemblages and benthic biota (e.g. sessile filter feeding communities) (McLean et al. 2017). IMMR activities may disturb these new communities; however, it is expected that recolonisation will occur.

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

Values and Sensitivities

Ancient Coastline at 125 m Depth Contour KEF

The Operational Area overlaps ~30 km^2 of the 16,190 km^2 Ancient Coastline KEF, which is ~0.2% of the KEF. The Operational Area represents a buffer around the Okha subsea infrastructure to facilitate vessel operations; the potential for seabed disturbance is much more localised (i.e. within tens of metres of the subsea infrastructure).

Benthic habitat surveys in the region (including within the Ancient Coastline at 125 m Depth Contour KEF) indicate that benthic habitats within the KEF are characterised by sand interspersed with areas of rubble and outcroppings of limestone pavement (AIMS 2014b, RPS 2011). Such habitats are widely distributed in the NWMR. No significant escarpments, species of conservation significance, emergent features or areas of high biological productivity characteristically associated with the Ancient Coastline KEF have been observed in the Operational Area. As noted in Section 4.7.5.1 the geomorphic feature the KEF is associated with is represented worldwide and represents the coastline during a previous glacial period. Therefore, potential impacts to this regional-scale KEF are expected to be localised with no lasting effect.

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[10]	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None identified.				
Good Practice				
None identified.				
Professional Judgement – Eliminate				
Vessels used for IMMR activities are DP-capable – use of DP instead of anchoring reduces potential impacts to benthic habitats	F: Yes CS: Minimal. Subsea support vessels undertaking IMMR activities routinely use DP to hold station	By using DP, the potential impacts to benthic habitats are reduced	Benefits outweigh the cost sacrifice	Yes **C 2.1**
Do not use ROV close to, or on, the seabed	F: No. The use of ROVs (including work close to or occasionally landed on the seabed) is critical; ROVs are an integral part of IMMR activities. CS: Not assessed, control not feasible	Not assessed, control not feasible	Not assessed, control not feasible	No
Professional Judgement – Substitute				
None identified				
Professional Judgement – Engineered Solution				
Monitoring of seabed surrounding subsea infrastructure.	F: Yes. ROV footage collected as part of subsea integrity surveys could be reviewed to observe and detect changes in benthic habitats. CS: Costs associated with reviewing collected footage	Limited environmental benefit (information) gained from monitoring benthic habitats.	Given the low sensitivity of the environment surrounding associated subsea infrastructure, any environmental benefit gained is outweighed by costs associated with implementing the control.	No
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls including regular maintenance and inspection activities appropriate to manage the impacts of seabed disturbance from planned activities. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				
Demonstration of Acceptability				
Acceptability Statement The impact assessment has determined that, given the adopted controls, seabed disturbance from operations and subsea activities is unlikely to result in an impact greater than a slight and short-term impact to benthic habitats, sediment and water quality. Further opportunities to reduce the impacts have been investigated above. The adopted controls are considered good oilfield practice/industry best practice. The potential impacts are considered broadly				

10 Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[10]***	***Benefit/Reduction in Impact***	***Proportionality***	***Control Adopted***
acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts of operations and subsea activities to a level that is broadly acceptable.				

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 2 Limit impacts to benthic habitats to Slight (E) beyond the physical footprint of the facility infrastructure during the Petroleum Activities Program.	**C 2.1** Vessels used for IMMR activities will be DP-capable.	**PS 2.1** Use of DP by IMMR activity vessels (no anchoring required) unless in an emergency or Woodside authorisation is provided.	**MC 2.1.1** Records demonstrate that subsea support vessels are equipped with DP system.

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6.6.3 Routine Acoustic Emissions: Generation of Noise during Routine Operations

Context	
Facility Layout and Description – Section 3.5 Operational Details – Section 3.6 Facility Operations – Section 3.6.9 Subsea Inspection, Maintenance and Repair Activities – Section 3.10	Species – Section 4.5.2

Impact Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Noise generated within the Operational Area from: • vessels and IMMR activities • helicopters • Okha FPSO and associated infrastructure.	-	-	-	-	-	X	-	A	F	-	-	LCS GP PJ	Broadly Acceptable	EPO 3

Description of Source of Impact

The FPSO, vessels, IMMR equipment and helicopters generate noise both in the air and underwater due to the operation of machinery, propeller movement, etc. Typical noise levels for these sources are provided in Table 6-3 and Table 6-4 with more detailed descriptions below. This noise contributes to and can exceed ambient noise levels, that range from around 90 dB re 1 µPa sound pressure level (SPL) under very calm, low wind conditions, to 120 dB re 1 µPa SPL under windy conditions (McCauley 2005).

Table 6-3: Indicative source characteristics of continuous underwater noise associated with the Petroleum Activities Program

Acoustic Noise Sources	Estimated SPL (dB re 1 µPa SPL) @1 m unless otherwise stated	Frequency Range (kHz)
Vessels (Continuous)		
FPSO*	181	Broadband
Support vessel using DP‡	187	Broadband
Wellhead, Flowlines and Subsea Infrastructure (Continuous)		
Wellhead§	113	Broadband
Choke valve§	155	Broadband

** Range provided was not measured at the noise source; therefore, this should be used as an indicative estimate only and cannot be used to estimate exposure thresholds closer to the source.*

§ McCauley (2002)

‡ McCauley (2005)

Vessels

Vessels may emit noise through the hull acting as a transducer (e.g. machinery vibration being converted to underwater noise), as well as through cavitation from fast-moving surfaces such as propellers and thrusters. The main source of noise from vessels (both FPSO support and subsea support vessels) relates to the use of DP thrusters (i.e.

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cavitation from thruster propellers). The vessels undertaking the Petroleum Activities Program are expected to spend time holding station during DP, which requires the use of thruster. Thruster noise (from cavitation caused by propellers) is typically the most significant noise source for vessels holding station, with other noise sources typically relatively minor (McCauley 1998).

Thruster noise is typically high intensity and broadband in nature. McCauley (1998) measured underwater broadband noise up to ~182 dB re 1 µPa at 1 m root mean square sound pressure level (rms SPL) from a support vessel holding station in the Timor Sea. It is expected that noise levels up to this this level may be generated by vessels using DP during the Petroleum Activities Program

All support vessels are required to comply with EPBC Regulation 2000 – Part 8 Interacting with Cetaceans to reduce the likelihood of collisions with cetaceans (refer to Section 6.7.3). Implementing this control may incidentally reduce the noise generated by vessels close to cetaceans as vessels are travelling slower; slower vessel speeds may reduce underwater noise from machinery noise (main engines) and propeller cavitation.

Helicopters

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Activities relevant to the Operational Area relate to helicopter take-off and landing on the FPSO (typically every two days) and potentially subsea support vessels. During these critical stages of helicopter operations, safety takes precedence. Helicopter flights are at their lowest (i.e. closest point to the sea surface) during these periods of take-off and landing from heli-decks, which constitutes a short phase of routine flight operations.

Wellhead, Flowlines and Subsea Infrastructure

The noise produced by an operational wellhead was measured by McCauley (2002). The broadband noise level was very low, 113 dB re 1 µPa, which is only marginally above rough sea condition ambient noise. For a few nearby wellheads, the sources would have to be very close (<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 near the wellheads would be expected to be ~113 dB re 1 µPa. This would drop very quickly to ambient conditions on moving away from the wellhead, falling to background levels within <200 m of the wellhead.

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

Acoustic measurements were undertaken on the noise generated by the operation of choke valves associated with the Angel facility (JASCO 2015)—a similar design is used across Okha subsea valves. These measurements indicated choke valve noise is continuous, and the frequency and intensity of noise emitted depends on the rate of production from the well. Noise intensity at low production rates (16% and 30% choke positions) were ~154–155 dB re 1 µPa, with higher production rates (85% and 74% choke positions) resulting in lower noise levels (141–144 dB re 1 µPa). Noise from choke valve operation was broadband in nature, with most of noise energy concentrated above 1 kHz. Noise from choke valve operation was considered minor compared to noise generated by vessels using thrusters in the area.

FPSO Machinery

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

Measurement of underwater sound taken at the Cossack Pioneer FPSO during 2002 during normal operations recorded broadband source levels up to 181 dB re 1 µPa. This included measurements when its propeller was in use (slowly turning) (McCauley 2002b). Source levels at the Cossack Pioneer were comparable to those recorded at Ngujima Yin FPSO during normal operations, which recorded average broadband source levels of 174 dB re 1 µPa under calm conditions (JASCO 2010). The higher source level recorded at Cossack Pioneer is considered representative of the source level at Okha FPSO at intermittent times when there is a requirement to use its main engine and propeller.

The HP and LP flare system generates noise from combustion. Noise from flaring represents a health and safety risk to personnel and was considered in the design of the Okha FPSO to manage the associated occupational health and safety risks (e.g. height specification of flare tower). Noise from flaring is emitted at the top of the flare tower, ~82 m above the main deck. Noise from the tip of the flare is not constrained and spreads spherically in all directions.

Subsea IMMR Activities

Subsea IMMR activities may result in localised, temporary increased in underwater noise. Sources proposed (Table 6-4) have frequency outputs ranging from 2 kHz (SBP Chirp) to 900 kHz (SSS).

High-frequency acoustic signals attenuate more rapidly underwater compared to lower frequencies. Given the operating frequency of the MBES and SSS, underwater noise generated from this equipment is expected to attenuate

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rapidly in the water column. The position of the acoustic source in the water column influences the horizontal transmission of noise. Sources towed close to the seabed, typically via an autonomous underwater vehicle have a smaller distance between the source and the seabed, reducing received levels in the horizontal direction due to seafloor scattering and absorption. Therefore, received noise levels at defined horizontal distances from the system are lower compared a surface-towed source. Given the nature and scale of expected IMMR activities, noise generated during these activities is expected to be similar to, or less than, noise generated by subsea infrastructure during routine operations.

Table 6-4: Frequency ranges of IMMR sources and marine fauna

IMMR source	Frequency Range (kHz) (Jimenez-Arranz et al. 2017)	Estimated range of Source Level (dB re 1 µPa SPL @1 m	Potential disturbance from acoustic source						
			Low-frequency cetaceans[1]	*Mid-frequency cetaceans[1]*	*High frequency cetaceans[1]*	*Marine turtles[3]*	*Whale sharks[2]*	*Fish – hearing specialists[4]*	*Fish – hearing generalists[4]*
Auditory frequency range (kHz)			***0.07 – 22***	***0.15 – 160***	***0.2 – 180***	***0.1–0.7***	***0.02–0.8***	***0.1–3***	***0.2–0.8***
MBES	12–700 (deep) 150–700 (shallow)	210–247	Deep only	✓	✓				
SSS	75–900	200–234		✓	✓				
SBP – Chirp	2–23	167–212	✓	✓	✓			✓	
SBP – Pinger	2–20	161–205	✓	✓	✓			✓	
Ultra-short baseline (USBL) / Acoustic Array	18–36	187–196	✓	✓	✓				

1 Southall et al. 2007

2 The estimated auditory bandwidth of whale sharks is unknown, a range of 0.02–0.8 kHz has been applied, which is the known approximate sensitivity of among sharks as outlined in Myrberg 2001. Although there are no known studies on whale shark auditory hearing bandwidths, research suggests the large hearing structures of the whale shark would be most responsive to long wave length, low-frequency sound (Myrberg, 2001).

3 The estimated auditory bandwidth of turtles is 0.1–0.7 kHz as determined by electro-physical studies (McCauley 1994)

4 Effects of seismic airguns and other sources of pulsed sound on marine fishes (URS 2007).

Impact Assessment

The Operational Area is in waters ~75 m to 130 m deep on the continental shelf. The fauna associated with this area will be predominantly pelagic species of fish, with migratory species such as turtles, birds, whale sharks and cetaceans present in the area seasonally. Two EPBC Act listed species have BIAs that overlap the Operational Area; these are discussed below.

The Ancient Coastline at 125 m Depth Contour KEF also overlaps the Operational Area. Fauna associated with the KEF, such as demersal fish, may also be impacted upon by noise emissions. Although the Ancient Coastline KEF may be associated with outcroppings of hard substrate, no evidence of significant reefs associated with such outcroppings has been found in the Operational Area. Note: Some demersal fish are also likely to be associated with subsea infrastructure such as the WC GEL (McLean et al. 2017).

Cetaceans

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

Southall et al. (2007), Finneran and Jenkins (2012) Wood et al. (2012), and more recently the US National Marine Fisheries Service (NMFS 2018) reviewed available literature to determine exposure criterion for temporary hearing threshold shift (TTS) and injury, referred to as the onset of non-recoverable permanent hearing loss (permanent threshold shift [PTS]). In addition, behavioural thresholds were taken from the NMFS. These thresholds are outlined in

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Table 6-5 and are considered appropriate for the assessment of impacts from acoustic discharges to cetaceans from the Petroleum Activities Program.

Table 6-5: Impulsive noise exposure thresholds at which physiological and behavioural impacts to cetaceans may occur

Reference	Impact Type	Minimum Threshold	
		SPL	***Sound exposure level (SEL)***
Southall et al. 2007	PTS (All Cetaceans)	230 dB re 1 µPa (peak)	198 dB re 1 µPa^2.s (m-weighted)
	TTS (Low Frequency Cetaceans)	224 dB re 1 µPa (peak)	192 dB re 1 µPa^2.s (m-weighted)
National Marine Fisheries Service (NMFS) 2014 and Southall et al. 2007	Behavioural Response Adults (Cetaceans)	160 dB re 1 µPa (rms)	-

To inform the assessment, the continuous source impact thresholds provided in Table 6-6 were considered in relation to the credible sources of acoustic emissions.

Table 6-6: Continuous sources – impact thresholds for environmental receptors

Receptor	Mortality and potential mortal injury	PTS	TTS	Behaviour
Low-frequency cetaceans*	n/a	198 dB re 1 µPa^{2}s M-weighted SEL	183 dB re 1 µPa^{2}s M-weighted SEL	120 dB re 1 µPa rms SPL
Mid-frequency cetaceans*	n/a	198 dB re 1 µPa^{2}s M-weighted SEL	183 dB re 1 µPa^{2}s M-weighted SEL	120 dB re 1 µPa rms SPL
High-frequency cetaceans*	n/a	198 dB re 1 µPa^{2}s M-weighted SEL	183 dB re 1 µPa^{2}s M-weighted SEL	120 dB re 1 µPa rms SPL

Note: A range of sound units are provided in the table above, reflecting the range of studies from which this data has been derived. The difference in units presents difficulty in reliably comparing threshold values. Where practicable, the threshold values have been compared with indicative sound sources levels of the same sound unit types to facilitate comparison. The sound units provided in the table above include M-weighted sound exposure level (SEL): a weighted sound metric that emphasises the audible frequency bands for the receptor groups – low, mid- and high frequency cetaceans. SEL units are time integrated and best suited for continuous noise sources, such as vessels holding station or continuous machinery noise.

Source: Based on based on Southall et al. (2007) and NMFS (2005)

Marine Turtles

Because of their rigid external anatomy, it is possible that sea turtles are highly protected from impulsive sound effects (Popper et al. 2014). However, McCauley et al. (2003), Popper et al. (2014) and O'Hara and Wilcox (1990) reference behavioural exposure thresholds for impulsive noise sources on caged green and loggerhead turtles and turtle injury thresholds (Table 6-7).

Moein et al. (1994) tested if hearing sensitivity of caged loggerhead turtles altered after being exposed to several hundred pulses within 30 to 65 m of a single airgun (pulse numbers and received sound levels not stated). Hearing was tested before, within a day, and then two weeks after exposure. About 50% of the exposed individuals indicated altered hearing sensitivity when tested within a day of their exposure, but compared to the pre-exposure tests, none provided any sign of altered hearing two weeks later. These results align with the thresholds provided in Table 6-7 that suggest the risk of PTS is low, even when close to the acoustic source. The thresholds listed in Table 6-7 and Table 6-8 are considered appropriate for the assessment of impacts from acoustic discharges to cetaceans from the Petroleum Activities Program.

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Table 6-7: Impulsive noise exposure thresholds for injury and behaviour response for marine turtles

Species	Received Level			Effect	Source
	(dB re 1 µPa RMS)	*(dB re 1 µPa pk)*	*(cSEL (dB re 1 µPa.s^2)*		
Sea turtles	-	>207	210	Injury	Popper et al. (2014)
Loggerhead turtle	175–176	-	-	Avoidance response	O'Hara and Wilcox (1990)
One green and one loggerhead turtle	166	-	-	Noticeable increase in swimming behaviour, presumed avoidance response	McCauley et al. (2003)
One green and one loggerhead turtle	175	-	-	Behaviour becomes increasingly erratic, presumed alarm response	McCauley et al. (2003)

Table 6-8: Continuous sources – turtle impact threshold for environmental receptors

Receptor	Mortality and potential mortal injury	PTS	TTS	Masking	Behaviour
Sea turtles†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low

Note: A range of sound units are provided in the table above, reflecting the range of studies from which this data has been derived. The difference in units presents difficulty in reliably comparing threshold values. Where practicable, the threshold values have been compared with indicative sound sources levels of the same sound unit types to facilitate comparison. The sound units provided in the table above include: relative risk (high, medium and low) is given for fish (all types), turtles and eggs and larvae at three distances from the source defined in relative terms as near (N), intermediate (I) and far (F) (after Popper et al. 2014).

† Popper et al. (2014)

Fish

Fish perceive sound through the ears and the lateral line, which are sensitive to vibration. Some species of teleost or bony fish (e.g. herring) have a structure linking the gas-filled swim bladder and ear, and these species usually have increased hearing sensitivity. These species are considered to be more sensitive to anthropogenic underwater noise sources than species such as cod (*Gadus* sp.), which do not possess a structure linking the swim bladder and inner ear. Fish species that either do not have a swim bladder (e.g. elasmobranchs and scombrid fish [mackerel and tunas]) or have a much-reduced swim bladder (e.g. flat fish) tend to have a relatively low auditory sensitivity. Considering these differences in fish physiology, Popper et al. (2014) developed sound exposure guidelines for fish; these are presented in Table 6-9 and Table 6-10 and are considered appropriate to assess potential impacts of acoustic discharges to fish.

Table 6-9: Impulsive noise exposure thresholds for different types of fish

Type of Fish	Recoverable Injury (PTS)	Temporary Threshold Shift (TTS)	Behaviour*
Type 1 – no swim bladder (particle motion detection)	>216 dB re 1µPa^{2}s (cSEL) or >213 dB re 1µPa (SPL peak)	>>186 dB re 1µPa^{2}s (cSEL)	(N) High (I) Moderate (F) Low
Type 2 – Swim bladder is not involved in hearing (particle motion detection)	>207 dB re 1µPa^{2}s (cSEL) or >203 dB re 1µPa (SPL peak)	>186 dB re 1µPa^{2}s (cSEL)	(N) High (I) Moderate (F) Low
Type 3 – Swim bladder involved in hearing (primarily pressure detection)	207 dB re 1µPa^{2}s (cSEL) or >203 dB re 1µPa (SPL peak)	186 dB re 1µPa^{2}s (cSEL)	(N) High (I) High (F) Low

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Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Source: Popper et al. (2014)

Table 6-10: Continuous sources – fish and turtle impact threshold for environmental receptors

Receptor	Mortality and potential mortal injury	PTS	TTS	Masking	Behaviour
Fish: no swim bladder†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder not involved in hearing†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing†	(N) Low (I) Low (F) Low	170 dB rms SPL for 48 hours	158 dB rms SPL for 12 hours	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles†	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low

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

- *Root mean square (rms) sound pressure level (SPL): root mean square of time-series pressure level, useful for quantifying continuous noise sources (as per SEL point above).*
- *Relative risk (high, medium and low) is given for fish (all types), turtles and eggs and larvae at three distances from the source defined in relative terms as near (N), intermediate (I) and far (F) (after Popper et al. 2014).*

Source: Popper et al. (2014)

Vessel Noise

Vessels holding station are considered to be the predominant noise source related to the Petroleum Activities Program. Using the thruster noise measured by Quijano and Mcpherson (2018) as an indicative value for the potential thruster noise generated by vessels during the Petroleum Activities Program and the thresholds presented in Table 6-6, the potential for noise-induced mortality or injury of cetaceans, fish, sea turtles and eggs/larvae is not considered credible. However, other impacts such as masking and behavioural impacts may occur. Modelling of vessel DP sound propagation was undertaken using dBSEA parabolic equation solver and DP vessel worst-case (rough) thruster noise of 187 dB re 1 µPa.

Potential impacts may include:

- Cetaceans: Potential behavioural disturbance out to ~5–7 km for cetaceans, likelihood of PTS or TTS is considered not to be credible, given individuals would need to be directly next to the noise source for prolonged duration and vessels are not point sources (i.e. sound is distributed from multiple locations of the vessel over a large area).
- Fish: Potential masking and behavioural disturbance at near and intermediate range; likelihood of PTS or TTS is considered not to be credible given fish would move away from the source. Site-attached fish (e.g. demersal fish) are not expected to be exposed to underwater noise above impact thresholds given water depths in the area where these fish may be more prevalent (i.e. the Ancient Coastline KEF).
- Turtles: Potential masking and behavioural disturbance at intermediate and far range, likelihood of PTS or TTS is considered not to be credible given turtles would need to be directly next to the noise source.

These estimated propagation ranges are considered to underestimate TL, and are, hence, inherently conservative, due to use of high-intensity thruster noise (i.e. thruster operating at full power in rough weather); most time thruster use is at lower than full power, with a concomitant reduction in cavitation noise intensity.

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

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IMMR Activities

JASCO (2013) conducted noise modelling for five low-energy survey instruments off the coast of California. Three of these instrument types are comparable to those outlined in Section 3—MBES, SSS, SBP (Chirp). All equipment types were modelled in the sandy bottom environment, similar to that of the Operational Area, and in 64 m water depth. Although the bathymetry, salinity, water temperature and sub seafloor sediment type may differ, given the similarities in equipment type, seafloor habitat and water depth, the modelling is considered comparable for the nature and scale of the low energy IMMR survey equipment.

The modelling reported distances to specific threshold levels for different types of marine mammals. Where applicable m-weighted R_{max} (the distance to the farthest occurrence of the threshold level) estimates were used. Since receptors identified in Section 4 include a greater range of species, unweighted R_{max}, was used for species where m-weighted estimates were not appropriate, which is considered conservative. The distances at which the 160 dB re 1 µPa (rms SPL) behavioural threshold was reached (R_{max}) are:

- MBES – 290 m
- SSS – 682 m
- SBP (Chirp) – 36 m
- acoustic transponder – 50 m.

The equipment listed in Table 6-3, which were not modelled in the JASCO study (2013), include the SBP (pinger) and USBL. The SBP (pinger) equipment operates at similar frequencies and pressure to the SBP (Chirp) and behavioural impact ranges are estimated to be similar.

Table 6-11: Summary of impact thresholds and R_{max} for different species

Species	Effect	Threshold (impulsive noise)		R_{max} (metres)				
		SPL	*SEL*	*MBES**	*SSS**	*SBP (Chirp)**	*SBP (Pinger)†*	*USBL†*
Cetaceans	PTS (all cetaceans)[1]	230 dB re 1 µPa (peak)	198 dB re 1 µPa².s (m-weighted)	N/A	N/A	N/A	N/A	N/A
	TTS (low-frequency cetaceans)[1]	224 dB re 1 µPa (peak)	192 dB re 1 µPa².s (m-weighted)	N/A	N/A	N/A	N/A	N/A
	Behavioural Response Adults (cetaceans)[1,2]	160 dB re 1 µPa (rms)	-	290	<693	<36	<50	<50
Marine turtles	Injury[3]	> 207 dB re 1 µPa (peak)	210 dB re 1 µPa².s	N/A	N/A	N/A	N/A	N/A
	Avoidance response[4]	175–176 dB re 1 µPa (rms)	-	N/A	N/A	<20	N/A	N/A
	Noticeable increase in swimming behaviour, presumed avoidance response[5]	166 dB re 1 µPa (rms)	-	N/A	N/A	<36	N/A	N/A
	Behaviour becomes increasingly erratic, presumed alarm response[5]	175 dB re 1 µPa (rms)	-	N/A	N/A	<20	N/A	N/A
Fish – Type 1	PTS[3]	>213 dB re 1 µPa (SPL peak)	>216 dB re 1 µPa².s	N/A	N/A	<1	N/A	N/A
	TTS[3]	-	>>186 dB re 1 µPa².s	<20	N/A	<20	N/A	N/A

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Fish – Type 2	PTS[3]	>203 dB re 1 µPa (SPL peak)	>207 dB re 1 µPa^2.s	N/A	N/A	<5	N/A	N/A
	TTS[3]	-	>186 dB re 1 µPa^2.s	<20	N/A	<50	N/A	N/A
Fish – Type 3	PTS[3]	>203 dB re 1 µPa (SPL peak)	207 dB re 1 µPa^2.s	N/A	N/A	<20	N/A	N/A
	TTS[3]	-	186 dB re 1 µPa^2.s	<20	<20	<50	N/A	N/A

Notes:

N/A stated where operating frequency is outside species auditable hearing range or where exceeding threshold is not credible

** R_{max} provided as presented in JASCO (2013)*

† R_{max} provided based on spreading calculations

1 *Southall et al. (2007)*
2 *NMFS (2013)*
3 *Popper et al. (2014)*
4 *O'Hara and Wilcox (1990)*
5 *McCauley et al. (2003)*

Helicopter Noise

Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface (and vice versa) – most noise energy is reflected). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface, angles >13° from vertical being almost entirely reflected (Richardson et al. 1995). Given this, and the typical characteristics of helicopter flights within the Operational Area (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance to marine fauna are not considered credible.

Wellheads, Flowlines and Okha FPSO Machinery Noise

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

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

Summary

<u>Cetaceans</u>

There is the potential for cetaceans to be exposed to underwater noise from vessels associated with the Petroleum Activities Program. However, as the peak underwater noise levels that may be generated by vessels and IMMR activities are below those resulting in injury or mortality, only behavioural impacts are credible out to 5–7 km from a DP vessel and up to 700 m from IMMR activities; any other potential impacts are considered negligible. Impacts are expected to be limited to localised avoidance of the noise source as there are no physical barriers in or near the Operational Area that may prevent cetaceans from moving away from vessels.

<u>Fishes</u>

Fish may temporarily be displaced from the immediate vicinity of a noise source; however, they would be expected to behave normally once the noise emissions ceased. A foraging BIA for whale sharks overlaps the Operational Area, and the species may be seasonally present (particularly between March and July) during their annual migration to and from the aggregation area off Ningaloo Reef. Whale sharks are not considered to be particularly vulnerable to underwater noise, and they do not have a swim bladder (considered to increase the vulnerability of a fish to noise-related impacts). Potential impacts to whale sharks from continuous noise (e.g. vessel noise) are expected to be no more than a short-term temporary displacement from noise sources while transiting the Operational Area. The IMMR activities noise sources are all higher in frequency (>2 kHz); therefore, they are mostly outside the range of fish hearing (2–4 kHz)

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Demersal and pelagic fish species will be present in the Operational Area, including fish communities associated with the Ancient Coastline at 125 m Depth Contour KEF. Impacts to fish are expected to be localised, of short duration, and restricted to behavioural responses such as avoidance of noise sources. Turtles Noise interference is listed as a key threat to threatened marine turtles identified as potentially occurring within the Operational Area (Table 4-3). Turtles may occur in the Operational Area although the area does not contain any known significant foraging habitat (i.e. no emergent islands, reef habitat or shallow shoals/banks). A flatback turtle internesting buffer BIA overlaps the Operational Area. However, the BIA only overlaps the Goodwyn-6 suspended exploration well section of the Operational Area and is ~18 km from the location of the Okha FPSO. Turtles may exhibit behavioural responses such as diving when exposed to underwater noise (e.g. vessel noise). IMMR-related noise is not expected to result in behavioural response, injury or mortality of individuals, or any other lasting effect, as the source frequency of proposed equipment (2–900 kHz) is well outside the known hearing frequency range of turtles (0.1–0.7 kHz).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[11]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Maintain helicopter separation from cetaceans as per EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07), which include the following measures: • Helicopters shall not operate lower than 1,650 feet or within a horizontal radius of 500 m of a cetacean known to be present in the area, except for take-off and landing.	F: Yes CS: Minimal cost. Standard practice.	Reduces likelihood of disturbance to cetaceans by maintaining separation distance.	Controls based on legislative requirements – must be adopted.	Yes **C 3.1**
Good Practice				
Implementing a shutdown zone around MBES, SSS and SBP for these fauna: • whales • marine turtles • whale sharks.	F: Yes. However, as equipment is underwater, effective implementation of zones is challenging from topsides observation. CS: Moderate. Requires the provision of a dedicated suitably trained crew member to undertake marine fauna observations.	Limited. The areas of disturbance for these devices are limited to within ~700 m of the source. Note: The frequency range of MBES and SSS are outside the estimated frequency hearing range of identified protected species (whales, turtles and whale sharks).	The source levels and frequency range of these devices are outside the estimated frequency hearing range of identified protected species (whales, turtles and whale sharks), so costs are considered disproportionate to benefits.	No
Professional Judgement – Eliminate				
Eliminating the use of DP on vessels during the	F: No. Both FPSO and subsea support vessels are required to reliably hold	Not considered, control not feasible.	Not considered, control not feasible.	No

[11] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[11]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Petroleum Activities Program.	station during the Petroleum Activities Program. Failure to do so may lead to loss of separation between vessels and infrastructure. This would result in unacceptable safety and environmental risk (loss of marine vessel separation has been identified as a MEE –07 Section 6.8.9). CS: Not considered, control not feasible.			
Restricting IMMR activities to outside ecologically sensitive periods for cetaceans and turtles	F: Yes. IMMR activities can be rescheduled; however, they may be required within ecologically sensitive periods for turtles and cetaceans to ensure equipment integrity and to reduce potential environmental and safety risks. CS. Moderate, costs associated with rescheduling activity.	Limited IMMR activities emit low-frequency sounds and are short and temporary in nature.	The source levels and frequency range of IMMR activities are outside the estimated frequency hearing range of identified protected species (cetaceans and turtles), so costs are considered disproportionate to benefits.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the continued impacts from routine acoustic emissions from vessels, helicopters, wellheads, flowline and the Okha FPSO (including machinery) to be ALARP in their current impact classification. As no reasonable additional/ alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, in its current state, impacts from routine acoustic emissions from vessels, helicopters, wellheads, flowline and the Okha FPSO (including machinery) represent a localised impact to marine fauna behaviour around and within the Operational Area, with no lasting effect. Further opportunities to reduce the impacts and risks have been investigated above. The impacts are consistent with good oilfield practice/industry best practice and are considered broadly acceptable in their current state. Therefore, Woodside considers standard operations appropriate to manage the impacts of acoustic emissions to a level that is broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 3 Limit impacts on fauna from noise emissions during the Petroleum Activities Program.	**C 3.1** Maintaining helicopter separation from cetaceans as per EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07), which includes this measure: • Helicopters shall not operate lower than 1,650 feet or within a horizontal radius of 500 m of a cetacean known to be present in the area, except for take-off and landing.	**PS 3.1** Interactions between helicopters and cetaceans will be consistent with EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07) Interacting with cetaceans.	**MC 3.1.1** Records demonstrate no breaches with EPBC Regulations 2000 Part 8 Division 8.3 (Regulation 8.07) Interacting with cetaceans.

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

Context	
Wells and Reservoirs – Section 3.5.2 Hydrocarbon and Chemical Inventories and Selection – Section 3.9 Subsea Inspection, Maintenance and Repair Activities – Section 3.10	Physical Environment – Section 4.4 Biological Environment – Section 4.5

Impact Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Discharge of subsea control fluids.	-	X	X	-	X	-	-	A	E	-	-	LCS GP PJ	Broadly Acceptable	EPO 4
Discharge of hydrocarbons remaining in subsea pipework and equipment during subsea intervention works (including pigging).	-	X	X	-	X	-	-	A	E	-	-			
Discharge of chemicals remaining in subsea pipework and equipment, or the use of chemicals for subsea IMMR activities.	-	X	X	-	X	-	-	A	F	-	-			
Discharge of minor fugitive hydrocarbons from wells and subsea equipment.	-	-	X	-	-	-	-	A	F	-				

Description of Source of Impact

Hydrocarbons and chemicals may be discharged because of planned routine and non-routine activities, including:

- operational discharges:
  - discharge of subsea control fluids – subsea control fluid is used to control valves remotely from the facility. It is an open-loop system, designed to release control fluid from the control system during valve operations (e.g. <6 L upon typical valve actuation)
  - potential non-routine hydraulic fluid discharge associated with umbilical system losses/weeps
  - discharge of minor fugitive hydrocarbon from wells and subsea equipment (e.g. weeps/seeps/bubbles)
  - discharge of chemicals introduced into subsea infrastructure and the production stream, either as process or non-process chemicals (e.g. corrosion inhibitors, biocides, scale inhibitors). Chemicals flow through the production process, with residual chemicals discharged as a component of the PW discharged overboard
- IMMR activities (nominal discharges described in Section 3.10.1.6):
  - discharge of residual hydrocarbons in subsea lines and equipment and small gas releases associated with isolation testing and breaking containment

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- discharge of residual chemicals in subsea lines and equipment, or the use of chemicals. These chemicals are used and discharged intermittently in small volumes. Small quantities of chemicals may remain in the flushed infrastructure, which may be released to the environment after disconnection.

Note: Subsea preservation and hydrotest fluids may be discharged subsea or after handling onboard the FPSO. Unplanned discharges of hydrocarbons and chemicals are considered in Section 6.7.1.

Impact Assessment

As a result of planned routine and non-routine hydrocarbon, subsea control fluid and chemical discharges, there is potential for slight, short-term localised decrease in water and sediment quality at discharge locations and ecosystem impacts. Subsea control fluid discharge locations are either at the SCMs or via the Okha FPSO.

Water Quality

Subsea control fluids are discharged in relatively small volumes from SCM vent ports during valve operations at or near the seabed. Once released into a low-sensitivity receiving environment, subsea control fluids are expected to mix rapidly and dilute in the water column. Hydrocarbons, which may be released during operational and IMMR activities (including pigging) that break containment of isolated subsea infrastructure, are buoyant and will float towards the surface. Given the water depth, pressure, and the small volumes released, these hydrocarbons are not expected to reach the sea surface. Rather, the release will disperse and/or dissolve within the water column. Chemicals may be discharged intermittently and in small volumes.

There is potential for slight, localised decrease in water quality at planned discharge locations and potential impacts on marine biota. Within the mixing zone impacts to pelagic fish are expected to be limited to avoidance of the localised area of the discharge and short-term, localised decline in planktonic organisms in the immediate vicinity of the discharge plume.

Sediment Quality

Accumulation of contaminants in sediments depends primarily on the volume/concentration of particulates in discharges or constituents that adsorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and the resuspension, bioturbation and microbial decay of those particulates in the water column and on the seabed. Some components of subsea control fluid are slower to biodegrade—these components make up ~0.35% of the total volume. Valve actuation discharges are frequent but low in volume (typically <6 L). The toxic component of a typically subsea control fluid release is <39 ml. Up to18 ml is readily biodegradable. The remaining 21 ml does not bioaccumulate but may be present in the sediments in the immediate vicinity of the discharge location. Given the frequency and volumes of hydrocarbon releases, accumulation in sediments is not considered likely.

Ecosystem

Sediments in the Operational Area are expected to be broadly consistent with those in the NWS Province (as described in Section 4.4.4), with filter feeders such as sponges, ascidians, soft corals and gorgonians associated with areas of hard substrate. The only areas of hard substrate expected in the vicinity are artificial habitat associated with subsea infrastructure. Subsea control fluid does not contain any components that are both bioaccumulative and non-biodegradable. Impacts to ecosystems are not expected due to the localised nature of discharge plumes and potential for sediment quality impacts.

Given the nature and scale of planned discharges, potential impacts are considered to be slight and short term (expected to recover once routine discharges cease).

Values and Sensitivities

KEFs

One KEF overlaps the Operational Area—Ancient Coastline at 125 m Depth Contour. No significant escarpments, species of conservation significance, emergent features or areas of high biological productivity characteristically associated with the Ancient Coastline KEF have been observed in the Operational Area (Section 4.5.1.4). Therefore, potential impacts to these regional-scale KEFs are expected to be negligible.

Demonstration of ALARP

Control Considered	*Control Feasibility (F) and Cost/Sacrifice (CS)*[12]	*Benefit in Impact/Risk Reduction*	*Proportionality*	*Control Adopted*
Legislation, Codes and Standards				
None identified.				
Good Practice				

[12] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[12]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Chemical Selection and Assessment Environment Guideline. • Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required. • If chemicals with a different OCNS rating, sub warning or non–OCNS-rated chemicals are required, chemicals will be assessed in accordance with the procedure prior to use.	F: Yes. Woodside routinely implements a chemical selection process based on OCNS at the Okha FPSO. CS: Minimal. The OCNS is widely used throughout the industry and chemical suppliers are aware of the requirements of the scheme.	Selection and assessment of chemicals in accordance with the Woodside process, reduces environmental impacts associated with planned chemical discharge.	Woodside's chemical selection process is used to ensure fluids discharged meet Woodside's chemical environmental risk assessment standards while still providing the required technical capability.	Yes **C 4.1**
Flush subsea infrastructure where practicable during IMMR disconnection activities to reduce volume/concentration of hydrocarbons released to the environment.	F: Yes. The subsea infrastructure has been designed such that much of the hydrocarbon-containing elements can be flushed back to the Okha FPSO. CS: Minor. Flushing may prolong the cessation of production required for subsea IMMR activities, leading to reduced production.	Flushing reduces the volumes/concentration of hydrocarbons release to the environment.	Benefit outweighs cost sacrifice.	Yes **C 4.2**
Limit the volume of subsea control fluid discharged to the marine environment by monitoring subsea control fluid use, investigating material discrepancies, and using subsea control fluid with dye marker.	F: Yes. The use of subsea control fluid is monitored to maintain adequate fluid in the system. CS: Minimal cost.	Limits the volumes of subsea control fluid discharge to the marine environment.	Benefit outweighs cost sacrifice.	Yes **C 4.3**
Monitor routine subsea control fluid discharges in sediments.	F: Yes. Subsea control fluid contains a small volume of low biodegradable components that will be dispersed via the release. CS: Monitoring costs. Costs associated with vessel hire and ROV for an in situ monitoring program would ~$100 K to $200 K (AUD). Can be	Planned discharge associated with valve actuation impact are ranked as slight and short term based on the volume, frequency, location and type of fluid discharged in an open-ocean environment.	Valve operations are the most frequent activity releasing up to 6 L of subsea control fluid each time at a location. Given the small volumes released the plume will be	No

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[12]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
	minimised if tied into existing monitoring programs.		highly localised. The toxic component of each release is 39 ml. 18 ml is readily biodegradable. The remaining 21 ml does not bioaccumulate but may be present in the sediments in the vicinity of the plume. To detect the impacts, any sampling would need to be in the immediate vicinity of subsea infrastructure. If localised impacts to sediment quality are detected, no additional controls can be implemented to reduce impact above those already adopted. Valve actuation is required to maintain technical integrity. Health and safety risks of working on vessels and near live subsea infrastructure to try to detect highly localised sediment impacts mean that the costs of implementing an in situ monitoring program are grossly disproportionate to the environmental consequence.	
Professional Judgement – Eliminate				
None identified.				

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[12]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Professional Judgement – Substitute				
Install closed-loop subsea control system.	F: No. Selection of subsea control system (open vs closed) is typically considered within the design phase of a project and therefore retrospective conversation to a closed-loop system is not considered technically feasible. CS: Not considered, control not feasible	Not considered, control not feasible.	Not considered, control not feasible.	No
Change out subsea control fluid.	F: No. Suitable compatible subsea control fluid alternative has not been identified. CS: Minimal. Ongoing cost of supplying subsea control fluid.	Potential reduction in environmental impact associated with an intermittent discharge associated with an open-loop subsea control system.	No reasonable alternative subsea control fluids have been identified. Woodside reviews chemicals with the aim of continuous improvement and is assessing options to replace the current subsea control fluid with a an alternative with improved environmental performance. Use of incompatible fluids has the potential to degrade seals in the subsea control system, which may lead to valves being inoperable increasing operational risk. Therefore, currently the risk is considered grossly disproportionate to the environmental benefit.	No (compatibility study in progress; refer to demonstration of acceptability statement below)
Professional Judgement – Engineered Solution				
Route hydrocarbons to vessel during	F: Yes. However, to do so would introduce significant	Small environmental benefit from preventing	Given the increased	No

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[12]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
disconnection of subsea infrastructure.	safety risks to the vessel crew (fire, explosion, asphyxiation). CS: Significant. Equipping and training crew onboard subsea support vessels to safely route hydrocarbons to the vessel would result in significant additional costs (in addition to the increased safety risk identified above).	low-concentration hydrocarbon discharge.	safety risk and the very low environmental impact from hydrocarbon releases during subsea IMMR activities, the cost of routing hydrocarbons to the vessel is grossly disproportionate to the environmental benefit.	

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of planned routine and non-routine hydrocarbon and chemical discharges. As part of the continuous improvement process alternative subsea control fluids with improved environmental performance are being investigated (described further in Table 7-7) If a suitable alternative is identified, a re-assessment of the controls required to reduce the environmental impact to ALARP will be undertaken. As no reasonable additional/alternative controls can currently be identified that would further reduce the impacts and risks without grossly disproportionate costs, the impacts and risks are considered ALARP.

Demonstration of Acceptability

Acceptability Statement

The impact assessment has determined that, given the adopted controls, planned routine and non-routine subsea hydrocarbon and chemical discharges are unlikely to result in an impact greater than slight, short-term impacts to water quality, marine sediment and ecosystem habitat. Further opportunities to reduce the impacts have been investigated above and are ongoing, as described below. The potential impacts are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts of planned routine and non-routine hydrocarbon and chemical discharges to a level that is broadly acceptable.

Continuous Improvement – Alternative subsea control fluid

A compatibility study is in progress to identify potential alternative subsea control fluid products that can be used with Okha's subsea system. However no suitable alternative has been identified at this time. Refer to Section 7.5.4.4 for Woodside's continuous improvement process and IS PO 10 in Table 7-7, which commits to evaluating alternative subsea control fluids for use on the Okha FPSO facility. The potential impacts from the current subsea control fluid are considered broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 4 Limit water quality impacts to Slight (E) from routine and non-routine hydrocarbon and chemical releases associated with subsea activities during the Petroleum Activities Program.	**C 4.1** Chemical Selection and Assessment Environment Guideline: • Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required. • If chemicals with a different OCNS rating, sub warning or non–OCNS-rated chemicals are required, chemicals will be assessed in accordance with the procedure prior to use.	**PS 4.1** All operational chemicals intended or likely to be discharged to the marine environment will be assessed and approved prior to use in accordance with the Chemical Selection and Assessment Environment Guideline (described in Section 3.9.2.4) to ensure the impacts associated with use are ALARP and acceptable.	**MC 4.1.1** Records demonstrate the chemical selection, assessment and approval process for operational chemicals is followed.
	C 4.2 Subsea infrastructure flushed where practicable during IMMR disconnection activities to reduce volume/concentration of hydrocarbons released to the environment.	**PS 4.2** Prior to disconnection, subsea infrastructure containing hydrocarbons will be flushed to the Okha FPSO (where practicable) to a hydrocarbon concentration where further dilution provides disproportionate cost to environmental benefit.	**MC 4.2.1** Records demonstrate subsea infrastructure flushing (to Okha FPSO) where practicable
	C 4.3 Monitor subsea control fluid use, investigate material discrepancies, to support identification of potential integrity failures.	**PS 4.3** Subsea control fluid use monitored and, where losses are unexplained, potential integrity issues are investigated.	**MC 4.3.1** Records demonstrate subsea control fluid use is documented, and unexplained discrepancies investigated.

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6.6.5 Routine and Non-Routine Discharges: Produced Water

Context		
Produced Water System – Section 3.6.3	Physical Environment – Section 4.4 Biological Environment – Section 4.5	Stakeholder Consultation – Section 5

Impacts Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Discharge of PW from FPSO.	-	X	X	-	X	X	-	B	E	-	-	LCS GP PJ RBA CV SV	Broadly Acceptable	EPO 5

Description of Source of Impact

Produced water (PW) is formation water (derived from a water reservoir below the hydrocarbon formation) or condensed water (water vapour present within gas/condensate that condenses when brought to the surface), or a combination of both. Separation of formation water from reservoir fluids is not 100% effective and separated formation water often contains small amounts of naturally occurring contaminants including dispersed oil, dissolved organic compounds (aliphatic and aromatic hydrocarbons, organic acids and phenols), inorganic compounds (e.g. soluble inorganic chemicals, dissolved metals) and residual process chemicals. A description of the existing PW system is provided in Section 3.6.3.

Produced water discharge is expected to continue for the duration of this EP. In 2018, ~5,823 m^3/day of PW was discharged from the Okha FPSO and discharge rates are expected to continue to increase as reservoirs age. The maximum daily discharge is 18,000 m^3/day (integrity limit); however, based on historical discharge rates actual discharge rates are expected to be much lower. Note: If no PW is discharged, this impact and associated EP requirements would cease.

Monitoring and Management Framework

This section describes the monitoring and management framework Woodside has developed to support the monitoring of PW discharges from offshore assets. In the absence of Commonwealth guidelines, the State Waters Technical Guidance: Protecting the Quality of Western Australia's Marine Environment (Environmental Protection Authority [EPA] 2016) has been considered and is consistent with the principles of the National Water Quality Management Strategy.

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and that require protection from the effects of pollution, waste discharges and deposits (Australian and New Zealand Guidelines [ANZG] 2018). The relevant environmental values considered are:

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

The relationship between key elements of ecosystem integrity, indicators and relevant monitoring activities undertaken on a routine and non-routine basis are shown in Figure 6-1. As per the EPA guideline (2016), the key elements to maintain ecosystem integrity have been identified as water quality, sediment quality and biological indicators (biota). By limiting the changes to these key elements to an acceptable level there is high confidence ecosystem integrity is maintained. For each element an indicator has been identified and monitoring designed to identify change. Monitoring change in water quality and sediment quality (at representative facilities) as well as investigating potential toxicity via

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whole effluent toxicity (WET) testing and implementing management to maintain acceptable level of change is standard industry practice in Commonwealth and State Waters. The relevant indicator to understand change in key elements and, therefore, potential for impact to ecosystem integrity, are physicochemical stressors, toxicants in water, biological indicators and toxicants in sediment. A number of trigger values for each indicator have been defined and are monitored to detect change. Trigger values serve as an early warning that potential changes beyond the acceptable limits may occur. The acceptable limits of change are no impacts from PW beyond the approved mixing zone. To determine if acceptable limits have been exceeded, routine monitoring of trigger values is undertaken. An approved mixing zone protects 99% of species, as calculated using the Warne et al. (2018) statistical distribution methodology on the results of direct toxicity assessment using sublethal chronic endpoints. The protection of 99% of species maintains a high level of ecological protection and represents no detectable change from natural variation (as per ANZG 2018).

The approved mixing zone boundary for Okha is 720 m. The justification for these limits of change being 'acceptable' is provided in the impact assessment section below.

Operational Monitoring

OIW monitoring is undertaken via an online analyser. When an elevated OIW concentration is detected, PW is automatically diverted to the PW tank and, if required, either slops tank. PW discharged from the slops tank is monitored by an additional OIW analyser. If both online OIW analysers are unavailable, manual sampling is undertaken. Online analyser information is sent via transmitter to the distributed control system (DCS) and is also captured within the process database. The DCS facilitates visibility in the control room, for manual or automated process control changes to be made, and/or initiate alarms (e.g. high OIW specification). The process database information is available onshore for analysis and trending. The results of manual sampling while the analyser is not available are stored in a spreadsheet contained on the Okha server.

Routine Monitoring

The monitoring and management framework is implemented in accordance with the Offshore Marine Discharges Adaptive Management Plan (OMDAMP). The OMDAMP details trigger values, routine monitoring assessment against trigger values, analytical methods, and actions when a trigger value is exceeded.

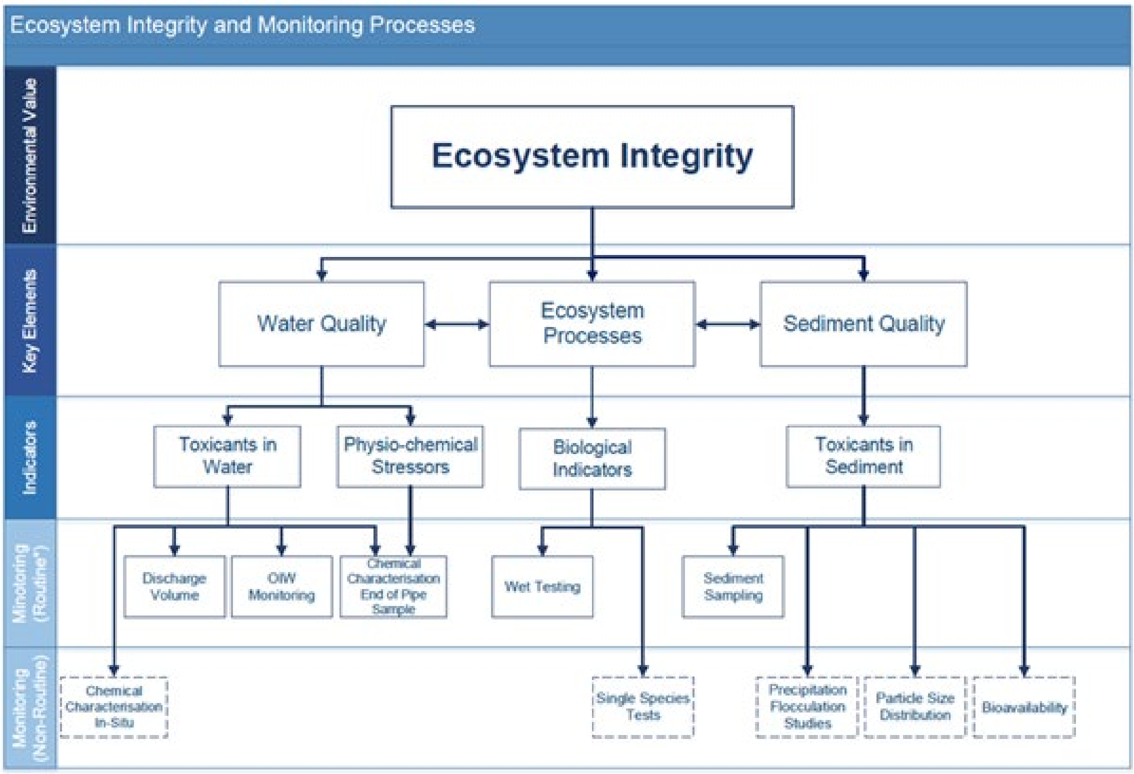

Figure 6-1: Ecosystem integrity and monitoring

The trigger values are applied through a risk-based approach that is intended to capture uncertainty around the level of impact, by staging monitoring and management responses according to the degree of risk to ecosystem integrity. The approach provides a level of confidence that management responses are not triggered too early (i.e. when there is no actual impact), or too late after significant or irreversible damage to the surrounding ecosystem (EPA 2016). Routine monitoring applicable to the facility, to compare against trigger values, is described in Table 6-12. Changes in water quality and raw PW toxicity can be detected early and can indicate the potential for an impact prior to an impact occurring.

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WET testing confirms if there is a potential for impact on biota. It is not appropriate to monitor for changes in species composition, diversity etc. as there are limited receptors in the approved mixing zone (a surface-buoyant plume) and such changes may be detected after an impact occurs rather than providing early detection. PW samples should represent normal operations and be undertaken during periods of normal production at the facility. Where practicable, samples are taken at a time when all (or as many as reasonably possible) PW-producing wells are online. The WET tests are undertaken on a broad range of taxa of ecological relevance for which accepted standard test protocols are well-established. WET tests mainly focus on the early life stages of test organisms, when organisms are typically most sensitive to contaminants; the tests are designed to represent local trophic level receptors. For WET testing, a range of tropical and temperate Australian marine species were selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols, and known reproducibility and sensitivity as test species. The dilutions required to protect 99% of species are calculated using the Warne et al. (2018) methodology. The protection of 99% of species maintains a high level of ecological protection at the boundary of the approved mixing zone.

Table 6-12: Trigger values used during routine monitoring

Parameter	Trigger Value Summary	Frequency
Chemical characterisation: end of pipe sample – physicochemical and toxicants	Results that are predicted to be higher than the 99% species protection guideline value at the approved mixing zone boundary and are above the results from the earlier toxicity year[1] or above the toxicity year when no guideline was available.	Annual, timed to consider if sample is representative.
WET testing[1]	The 99% species protection safe dilutions derived from WET testing species sensitivity distributions are not predicted to be achieved at the boundary of approved mixing zone and are higher than previous years.	Three-yearly. Conducted in parallel with annual chemical characterisation where feasible.
Review of continuous operational monitoring results	Increases in the average monthly OIW concentration by 5 mg/L for more than six consecutive months or by 10 mg/L for two consecutive months.	Monthly

Note:

[1] Earlier toxicity year means the year in which the most recent WET test occurred.

If a trigger value is exceeded it raises uncertainty around whether the environmental value is being protected, and further investigation is required (Figure 6-2).

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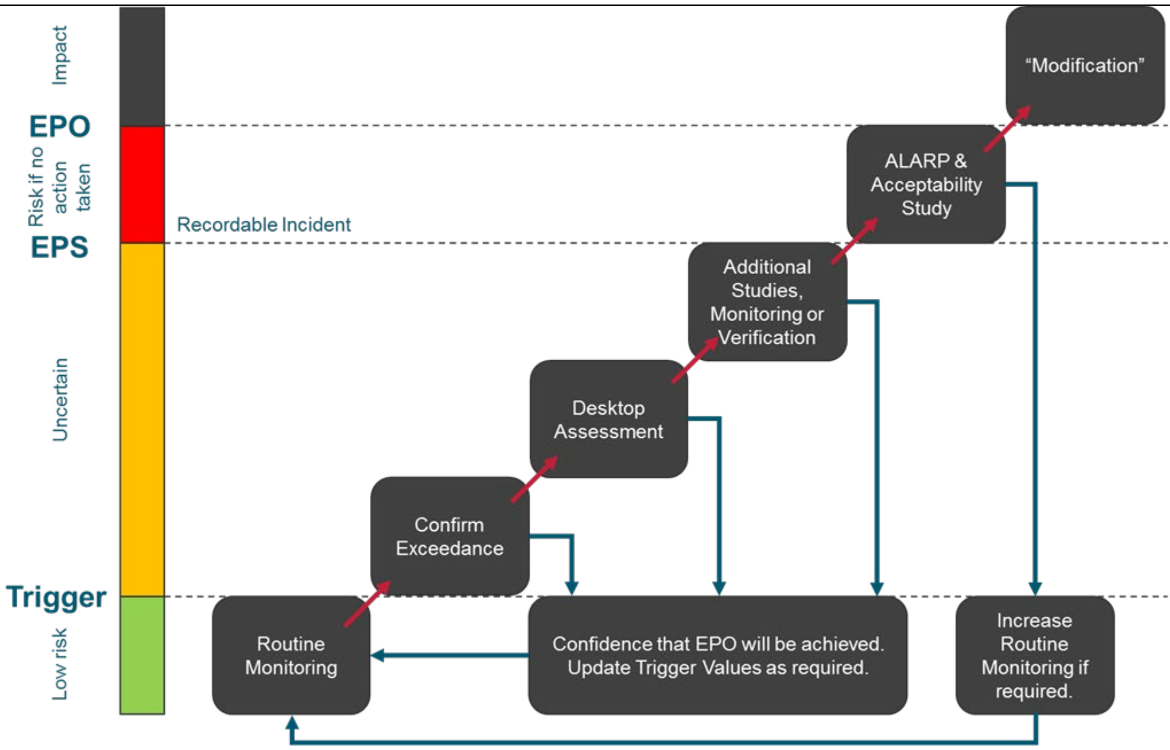

Figure 6-2: Routine monitoring and adaptive management framework for produced water

Further Investigations

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

A range of methods can be used to detect trigger value exceedances (e.g. relative percentage difference, control charts, multivariate analysis), depending on the dataset available. An appropriate method is selected as described in the OMDAMP due to the variable nature of environmental data. If critical data are not available, the desktop study identifies potential data gaps and may recommend additional non-routine studies and/or monitoring to ensure the assessment is appropriately undertaken. The purpose of the further investigations is to provide certainty that the EPS has been achieved, if a trigger value has been exceeded. The key investigation steps are described below:

1. **Confirm the trigger value has been exceeded** – Review quality assurance and quality control, methodology and possible sources of contamination to determine if the results are reliable, or if any factors have occurred that may compromise the integrity of the monitoring or data.
2. **Complete a desktop assessment to understand whether the EPS is at risk** – If a trigger value is confirmed to be exceeded, multiple lines of evidence are considered including historical and current data from routine and non-routine monitoring and studies. This assessment shall consider whether there is adequate evidence to demonstrate that acceptability criteria have been met and ecological integrity is not at risk (EPS not breached). If the desktop assessment determines the existing body of evidence is insufficient, it shall outline what additional monitoring or studies are required. The desk top assessment ensures monitoring programs are designed and implemented to provide robust findings based on valid survey design. Potential additional monitoring/studies may include, but are not limited to:
   - single species test (collected annually in parallel with routine chemical characterisation if further investigation is required)
   - dilution modelling and/or studies
   - settling velocity analysis
   - metal bioavailability
   - scanning electron microscopy and particle size distribution analyses
   - in situ water quality chemical characterisation.

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

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

The desktop assessment may consider a review of trigger values to ensure they are appropriate or an ALARP/Acceptability study to determine what additional controls can be implemented to ensure the changes are acceptable.

ALARP/Acceptability Study

An ALARP/Acceptability study is conducted once it has been determined, as a result of further investigations, that there is potential to exceed the acceptable limits of change.

The ALARP/Acceptability study shall be conducted in accordance with the ALARP Demonstration Procedure, to determine additional controls that may be necessary. Additional controls may include technology or process upgrades or reservoir management. Woodside will implement the additional controls identified in the ALARP/Acceptability study to maintain acceptable discharge of PW. Field validation of model assumptions, and additional monitoring to assess whether impacts have been realised, is considered

Impact Assessment

Potential impacts of PW discharge include:

- changes to water quality
- toxicity to biota
- changes to sediment quality.

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

Potential Impacts to Water Quality

PW is discharged from the FPSO either directly overboard below the water (Section 3.6.3) or via the slops tank at the surface. The plume initially plunges and then rises to the surface as positively buoyant plume in both scenarios. Potential impacts to water quality have been assessed through chemical characterisation of PW and potential discharge volumes.

Chemical Characterisation of PW (Physicochemical Parameters and Toxicants)

Historical monitoring indicates the approved mixing zone has not been exceeded and provides high confidence that impacts from PW discharge are highly localised and pose negligible effects to environmental receptors. Samples of undiluted PW collected annually from the end of pipe between 2011 to 2018 were analysed for key physicochemical parameters and toxicants. In most cases, results are below trigger values, or similar to the results of chemical characterisation when the previous year's WET testing was undertaken (i.e. previous toxicity year).

Two metals, BTEX (benzene, toluene, ethylbenzene, and xylene compounds) and phenols were sometimes present at levels above the ANZG (2018) guideline values at the end of the pipe (Jacobs 2018a). To achieve the 99% species protection guideline values, the highest dilution required was 168 for the derived C6–C36 guideline value. Modelling (Jacobs 2018b) predicts 903 and 3,131 dilutions were achieved 720 m from discharge point at the maximum discharge rate (18,000 m^3/day) and 2017 average discharge rate (5,209 m^3/day) respectively. Routine chemical characterisation has indicated a stable discharge with no additional non-routine monitoring triggered.

There is potential for a slight localised decrease in water quality at the discharge location within the mixing zone and adverse effects on marine biota. Within the approved mixing zone, impacts to pelagic fish are expected to be limited to avoidance of the localised area of the plume and short-term localised decline in planktonic organisms in the immediate vicinity of the discharge plume.

Discharge Volumes

The average daily volume of PW discharged from the facility in 2018 was 5,823 m^3/day and PW discharges have consistently been lower than the maximum capacity of the PW system that was modelled (18,000 m^3/day). Based on historical discharge rates, future discharges are expected to increase as the fields age.

Potential Impacts to Biota

Most treated PW has low to moderate toxicity (Neff et al. 2011), with actual toxicity of discharge dependant on the chemical constituents of the formation water and any added process chemicals, the level of treatment and dilution with

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condensed water prior to release, and the dilution of the discharge as it mixes with sea water. Most hydrocarbons in PW are considered non-specific narcotic toxins with additive toxicities; therefore, the toxicity of a PW, in part, depends on the total concentration and range of bioavailable hydrocarbons (Neff 2002). Potential impacts of PW to biota have been assessed through WET testing and dilution modelling to verify the approved mixing zone is being achieved.

WET Testing

WET testing has been undertaken to allow for interactions between toxicants and considers toxicants that cannot readily be measured or are not known to be present in the sample. Routine WET testing was completed as required by the previous revision of the EP in 2017 and 2014 (Table 6-13). The number of dilutions required to achieve 99% species protection safe dilutions is similar to the previous testing.

Table 6-13: Protection Concentration (PC) 99% concentrations and safe dilutions

Species Protection Level	Predicted No Effect Concentrations (PNEC) concentrations		
PCx	***2006***	***2014***	***2017***
PC99 (50)	0.31 (1 in 320)	0.15 (1 in 670)	0.29 (1 in 345)

Determination of Approved Mixing Zone

To determine the potential impact of the PW to the marine environment, modelling was conducted to predict the distance at which 99% species protection safe dilutions are achieved, using the most recent WET testing results available at the time to reflect the current potential toxicity (Table 6-13). The latest modelling study was carried out in 2018 and informs this impact assessment (Jacobs 2018).

Model simulations of dilutions were undertaken for three main seasons prevalent on the NWS, based on measured current and wind data. Ocean current data was collected at multiple depths through the water column. As the modelling of ocean current speed and direction varies substantially within each season, the full current records were analysed to select periods typical of the three seasons on the NWS but erring on the side of low current speeds to give conservative model results (Jacobs 2016).

Further to these hydrodynamic inputs, the formation water discharge model produced by Rob Phillips Consulting was validated in 2006 using the results from a dye dispersion study (Oceanic Field Services 2006). The predicted plume dilutions reasonably matched those measured.

The results from the WET testing undertaken in 2017 were used to develop PNEC values that were inputs to the model. The four-day averaged PW concentrations provide estimates of the mean in situ exposure concentration. The four-day PEC (Predicted Effects Concentration) value is used to determine the PEC/PNEC ratios and the distances from the discharge point at which 99% species protection safe dilutions (PC99) are achieved, based on the 2017 discharge rate (5,209 m^3/day) and maximum discharge rate (18,000 m^3/day). The modelling shows a surface-buoyant plume that is readily diluted to 99% species protection safe dilution within 720 m of the discharge location under worst-case conditions at actual and maximum discharge rates. Therefore, it is proposed to maintain a 720 m approved mixing zone to reflect 99% species protection safe dilutions at the maximum expected discharge 18,000 m^3/day.

Impacts to AMPs, KEFs and BIAs

The Okha FPSO is moored ~10 km from the nearest KEF (the Ancient Coastline at 125m Depth Contour) and 92 km from the Montebello AMP (Figure 6-3). Glomar Shoal is ~12 km away from the mixing zone, further than the Ancient Coastline KEF. Given PW forms a buoyant plume and the distance from the discharge source, no impacts to the Marine Park or KEF are anticipated. Routine monitoring (end of pipe chemical characterisation and WET testing) detects changes at the approved mixing zone boundary. If trigger values are predicted to be exceeded at this distance further investigation is required as described above. This may include reviewing single species toxicity test results, additional WET testing or in situ monitoring. If trigger values are not exceeded, there can be high confidence that maximum ecological protection is achieved by the Montebello AMP.

The approved mixing zone is within the foraging BIA for whale sharks; however, given the localised area of impact and that whale sharks are transiting the area, no impacts are expected.

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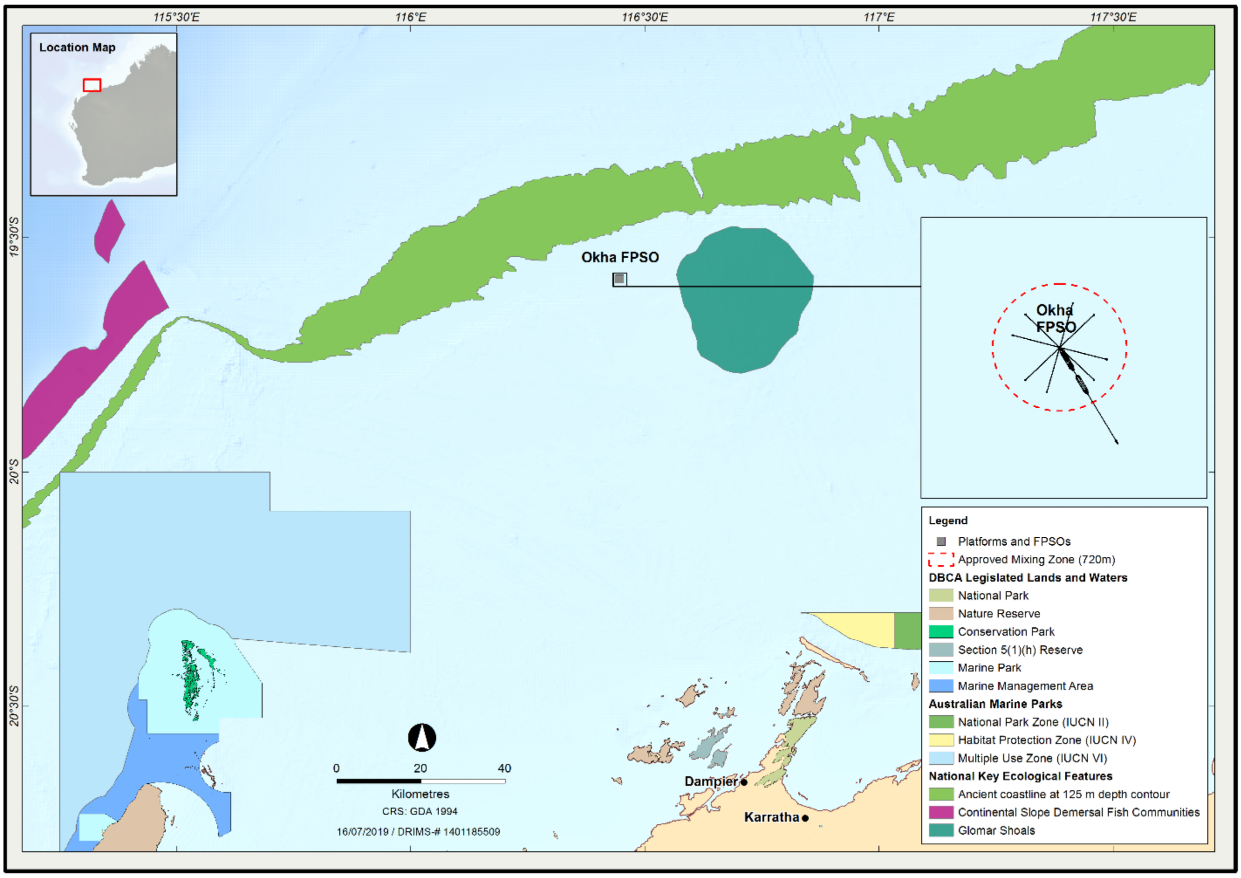

Figure 6-3: PW approved mixing zone relative to AMPs and KEFs

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 facility is ~6 mg/L (Jacobs 2018) Bioaccumulation of BTEX compounds has been observed to occur in the laboratory, but only at concentrations far in excess of that discharged from the Okha FPSO (e.g. refer to Berry 1980); hence, it is unlikely BTEX would bioaccumulate at the exposure concentrations that may be experienced by biota around the FPSO.

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

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

Concentrations of MAH, PAH and phenol as determined by Neff et al. (2011) were orders of magnitude higher in PW than in ambient seawater. There was no evidence of MAH or phenol being bioconcentrated. All MAH and phenol were either not detected (>95% of tissue samples) or were present at trace concentrations in all invertebrate and fish tissue samples. Concentrations of several petrogenic PAHs, including alkyl naphthalenes and alkyl dibenzothiophenes, were

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slighter, but significantly higher in some bivalve molluscs but not fish, from discharging than from non-discharging facilities. These PAH could have been derived from PW discharges or from tar balls or small fuel spills. Concentrations of individual and total PAH in mollusc, crab and fish tissues were well below concentrations that might be harmful to the marine animals or to humans who might collect them for food at offshore facilities (Neff et. al. 2011). Therefore, bioaccumulation is unlikely to result in increased levels of BTEX in biota surrounding Okha; however, there may be an elevation in PAH levels. The results from Neff et al. (2011) can be used to infer the very low potential for adverse bioaccumulation effects to marine organisms, or to humans, if they were to consume any affected fish, molluscs or crabs found on upper near-surface legs of the facility. 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, as described below. Potential health risks are unlikely as a result of negligible exposure: the PSZ prohibits fishing from or near the facility as there is very little or no activity within the Operational Area. The findings of the Routine Sediment Sampling/Analysis and Water Quality Monitoring field studies completed in 2014 at Okha (BMT Oceanica 2015) validated the conclusion that states, '*the potential environmental impact associated with bioaccumulation of PW constituents in the water column and in the sediments, is considered to be very low and limited to a potential localised effect on a small number of non-threated species in waters immediately surrounding each facility'*. Given the nature of the PW discharge from the FPSO, the potential for bioaccumulation of PW contaminants (in particular BTEX) is considered to be highly localised with no lasting effect.
Potential Impacts to Sediment Quality
Potential impacts to sediment quality were assessed through sediment surveys at nearby facilities and supported by the results of flocculation studies and potential for impacts to water quality. <u>Toxicants in sediments</u> Accumulation of PW contaminants in sediments depends primarily on the volume/concentration of particulates in PW discharges or constituents that adsorb onto seawater particulates, the area over which those particulates could settle onto the seabed (dominated by current speeds and water depths), and the resuspension, bioturbation and microbial decay of those particulates in the water column and on the seabed. As described above, the potential for PW to impact sediment, based on chemical characterisation, is unlikely due to the concentrations observed. The plume is buoyant, due to lower salinity and/or higher temperature than surrounding sea water. Therefore, potential contaminants in the PW discharge may be introduced into sediments around the FPSO through precipitation of soluble contaminants and flocculation and sedimentation of the particles in the PW plume. Studies into potential sediment accumulation from PW discharge have been undertaken by Woodside, including analysis of a sample of PW from the facility (Jacobs 2016). The study found that the PW at Okha has very small amounts of solid material, with very little potential of settling out due to small particle sizes (100% particles <40 µm), and that it is unlikely to flocculate. Dr Graeme Hubbert categorised particulate behaviour based on oceanographic experience and mathematical calculations using settling rates and resuspension velocities for various particle sizes. He determined that particles of a size 1 to 5 µm would never permanently settle out of the water column, and that particles from 5 to 40 µm would not permanently settle out of the water column, unless they were in very deep water (>5000 m) or in areas where hydrodynamic conditions were very weak and did not continuously resuspend the particles (SKM 2013). All the particles in Okha PW were smaller than 40 µm (Jacobs 2016), and therefore have little chance of settling within the dynamic open ocean environment surrounding the facility. In 2014, sediment sampling was conducted at Okha to verify impacts to sediment were not observed from PW discharges (BMT Oceanica 2015). The Australian and New Zealand Environment and Conservation Council (ANZECC) / Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000a) Australian interim sediment quality guideline (ISQG) -Low and -High values for metals with existing guidelines were met in all samples at all sites around the Okha FPSO. Further routine sediment sampling is not proposed due to the stable nature of the discharge. Non-routine sampling may be triggered as described in the OMDAMP.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[13]***	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None identified.				
Good Practice				
Chemical Selection and Assessment Environment	F: Yes. Woodside routinely implements a chemical	Selection and assessment of	Woodside's chemical selection	Yes

[13] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[13]	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
Guideline (Woodside Doc No. WM0000MG9905057): • Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required. • If chemicals with a different OCNS rating, sub warning or non–OCNS-rated chemicals are required, chemicals are assessed in accordance with the procedure prior to use.	selection process based on OCNS at Okha. CS: Minimal. The OCNS is widely used throughout the industry, and chemical suppliers are aware of the requirements of the scheme.	chemicals in accordance with the Woodside process reduces environmental impacts associated with planned chemical discharge.	process is used to ensure fluids discharged meet Woodside’s chemical environmental risk assessment standards while still providing the required technical capability.	**C 4.1**
Monitor and manage OIW concentrations in accordance with former Paris Convention 1997/16 (PARCOM) Annex 3 methodology: • Limiting average PW OIW to less than 30 mg/L (over a rolling 24-hour period).	F: Yes. CS: Monitoring and implementation costs. Standard practice. The 30 mg/L limit proposed is a legacy of the former OPGGS Environment Regulations 29 and 29A repealed in 2014. Reduction of this limit is not considered feasible or practicable. The current limit is effective in managing risk of PW discharge.	Limiting OIW concentrations within PW reduces impacts to the environment.	The adoption of a limit ensures PW OIW is controlled.	Yes **C 5.1**
Inboard off-specification PW to maintain OIW concentrations below 30 mg/L.	F: Yes CS: Monitoring and implementation costs. Standard practice.	Inboarding of PW is a contingency measure to ensure that rolling 24-hour period limits are not exceeded, even if a temporary spike in OIW concentration occurs.	If the facility exceeds 30 mg/L for a short period, which places the rolling 24-hour period limit at risk, the facility is able to inboard PW for further separation in the PW tank and/or slops tank, to ensure a breach of the OIW limit does not occur. This control achieves the same performance standard as the monitoring of OIW concentrations control.	Yes **C 5.2**
Implement the Monitoring and Management Framework for PW including:	F: Yes. CS: Monitoring costs. Standard practice.	The OMDAMP manages significant changes to the PW discharge	Woodside has been operating a number of offshore facilities (including	Yes **C 5.3**

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[13]	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
• monitoring of PW discharge volume • chemical characterisation • WET testing.		characteristics (i.e. volumes, OIW concentration, chemical dosage) that may cause an increased impact or risk to the marine environment. By implementing the OMDAMP, potential risks to the environment are reduced.	Okha) for a considerable period and has developed the OMDAMP based on operational experience. The OMDAMP considers risk-based adaptive management measures.	
Online monitoring and/or procedural controls in place to monitor and control PW OIW concentrations and prevent discharge of PW with high OIW concentrations. Process performance monitored by OIW analyser. Conduct manual sampling on a 6-hourly basis if online analyser is unavailable, where safe and practicable to do so.	F: Yes. CS: Minimal cost. Standard practice.	The OIW analyser provides optimal process control and safeguarding to monitor, control and prevent discharge of PW with high OIW concentration to the environment. High OIW PW is inboarded for further separation then a second OIW analyser is installed to monitor, control and prevent discharge of PW with high OIW concentration to the environment after inboarding. Monitoring of OIW concentrations when online analyser unavailable when safe and practicable to do so.	Control is WMS requirement – must be adopted.	Yes **C 5.4**
The online analysers are calibrated with a manual sample analyser in accordance with Laboratory Procedure AN-M-140.	F: Yes CS: Monitoring and implementation costs. Standard practice.	Calibration of equipment to maintain quality control.	Calibrations undertaken at appropriate frequency to maintain quality control and in line with procedures.	Yes **C 5.5**
Professional Judgement – Elimination				
Reinjection of PW into reservoirs.	F: Potentially feasible – some technical risk associated with reservoir uncertainty. CS: Significant. The reinjection of PW would require significant modification to the facility, including drilling injection	The environmental impacts in the approved mixing zone around the facility would be eliminated whilst reinjection is online. Long-term biological impacts from PW	As part of the 2015 PW study into treatment, Woodside examined the potential for reinjection of PW at NWS facilities.	No

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[13]***	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
	wells. This would require considerable design and construction costs. Previous studies indicate a cost in excess of $20 million AUD capital expenditure (CAPEX) for PW reinjection, with an estimated operating expenditure (OPEX) cost of $1 million. Additionally, drilling rig activities associated with drilling an injection well introduce environment impacts (from cuttings discharges) and health and safety risks associated with the drilling campaign.	that are outside acceptable limits of change (i.e. impacts to ecosystems' integrity from contaminant accumulation in sediment and bioaccumulation effects over time) are prevented by the PW Monitoring and Management Framework. Currently, PW does not represent a sediment accumulation or resulting bioaccumulation risk (refer to potential impacts to sediment quality for more detail).	Woodside has not identified a suitable reservoir, and such an option would likely require additional drilling activities to be undertaken. Reinjection is not feasible unless a suitable reservoir is identified. It is not feasible to reinject into a shut-in production well because the wells continue to have very high reservoir pressure, which would require significant facility modifications to overcome. Drilling and subsea work activities to establish a reliable PW reinjection well and subsea infrastructure also introduce significant complexity, risk and cost. Retrofitting PW topsides reinjection equipment to the FPSO introduces significant modifications, which pose safety risks on an operational facility. Together the significant retrofit risks, associated environmental impact (drilling and subsea construction) and introduced health and safety risks are considered significantly disproportionate to the potential slight environmental impact improvement. As such, no further engineering design	

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[13]	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
			or screening studies reporting is considered reasonably practicable. For Type B impacts, it is appropriate to consider case-specific drivers to ALARP management. The lack of a suitable reservoir contrasts with Woodside's facilities that currently reinject PW. At a similar FPSO, for example, water reinjection is required to maintain reservoir pressure for production and was a key part of the Field Development Plan to optimise overall field recovery. As PW alone is not sufficient to maintain reservoir pressure, sea water is used to make up the balance. Therefore, given the significant economic benefits associated with reinjection at this FPSO the ALARP outcome is different to Okha. The reinjection of PW would also introduce additional sources of environmental risks and impacts, such as those associated with drilling injection wells (e.g. drilling cuttings) and maintaining injection capability (e.g. increased greenhouse gas	

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[13]***	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
			emissions from power generation for pumps, increased chemical usage). Given the localised, slight, impact of PW discharges, and the considerable costs involved in developing a PW reinjection capability for the Okha, implementation risks and environmental impacts (greenhouse gas, chemical use), the costs are grossly disproportionate to the potential environmental benefit gained.	
Professional Judgement – Substitution				
None identified.				
Professional Judgement – Engineered Solution				
Chemical injection of water clarifier to reduce OIW concentration.	F: Potentially feasible. CS: Moderate. Initial cost of modifying production system to include chemical dosing point. Ongoing cost of chemical procurement.	C: Potential minor reduction in OIW concentration; however, does not reduce the overall consequence rating. Further, this results in additional chemical load, and lifecycle environmental footprint associated with packaging, logistics, waste management and potential process upsets.	The discharge of the clarifying agent with the PW stream may result in additional toxic effects. Ongoing chemical consumption would also incur OPEX. Given the nature and scale of impacts forming the current PW discharge, the cost of developing a chemical injection is disproportional to the environmental benefit.	No
Adopting a tertiary treatment stage to reduce OIW concentration.	F: Potentially feasible. Large deck space would be needed which is not currently available. CS: Significant cost. Deck reinforcement or cantilevers required, as well as high	Potential minor reduction in OIW concentration; however, does not reduce the overall consequence rating. Further, there is	Macro porous polymer extraction equipment is large and heavy, requiring deck reinforcement or cantilevers. It is	No

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[13]	***Benefit in Impact Reduction***	***Proportionality***	***Control Adopted***
	cost associated with these maintenance-intensive technologies. Previous studies for a similar NWS facility indicate a cost of $5–15 million CAPEX for tertiary treatment stage technology, with an estimated annual OPEX cost of $250,000–750,000 AUD.	very little deck space available at Okha for additional treatment equipment.	also maintenance intensive. This introduces significant costs and additional risk from exposure of personnel. Additionally, these options tend to have high power consumption. The adoption of tertiary treatment is not currently considered ALARP because the additional costs and risks associated with this option are considered disproportionate to the OIW benefit.	
Professional Judgement - Procedure and Administration				
None identified.				
Risk Based Analysis				
Application of Woodside's Risk Management Procedures and implementation of the OMDAMP provides for assessment of PW impacts, identification of changes to discharges, systematic assessment of risks and ongoing assessment/monitoring of discharge streams to reduce risk to ALARP, which includes: • ongoing hazard identification, risk assessment and the identification of control measures • ongoing PW discharge monitoring.				
Company Values				
Corporate values require all personnel at Woodside to comply with appropriate policies, standards, procedures and processes while being accountable for their actions and holding others to account in line with the Woodside Compass. As detailed above, the Petroleum Activities Program will be undertaken in line with these policies, standards and procedures, which include suitable controls to manage PW discharge				
Societal Values				
Due to the Petroleum Activities Program's proximity to sensitive receptors and potential uncertainty around PW discharges, the PW discharge consequence rating presents a Decision Type B in accordance with the decision support framework described in Section 2.6.1. Extensive consultation was undertaken for this program to identify the views and concerns of relevant stakeholders, as described in Section 5.				
ALARP Statement On the basis of the environmental impact and risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of PW discharge. Woodside has undertaken RBA (PW discharge modelling) to inform the evaluation and assessment of environmental impacts and risks. Woodside also implements a risk-based adaptive OMDAMP. The outcomes of both the modelling studies and long-term monitoring were considered in determining the ALARP position. As no reasonable additional/alternative controls are currently identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts are considered ALARP.				

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Demonstration of Acceptability

To assess and determine the acceptable limits of impacts from PW discharges, Woodside has considered appropriate guidelines, principles of ESD, CVs and SVs. Refer to the details below for additional discussion.

Other Requirements (includes laws, polices, standards and conventions)

The adopted controls and acceptability assessment have considered regulatory guidance, in particular WA EPA (2016) Technical Guidance: Protecting the Quality of Western Australia's Marine Environment and the ANZECC/ARMCANZ (2018) guidelines. Both sources of regulatory guidance provide that environmental values should be identified, and levels of ecological protection should then be set. To ensure ecosystem health is maintained overall, the cumulative size of the areas where lower levels of ecological protection apply should be proportionally small compared to the areas designated high and maximum. The ANZECC/ARMCANZ (2018) guidelines similarly provide guidance that levels of protection should be identified, based on the environmental values to be protected.

The Monitoring and Management Framework aligns to the levels of protection described by both WA EPA (2016) Technical Guidance and the ANZECC/ARMCANZ (2018) guidelines through the acceptable limit of change. The level of ecological protection provided to sensitive receptors (located 10 and 92 km away) is consistent with the North-west Marine Parks Network Management Plan (2018). By monitoring and managing to the 99% species protection safe dilutions (high level of ecological protection) at 720 m, there can be high confidence that any potential for impacts can be detected and managed via the OMDAMP.

Principles of ESD

Woodside has a strong history of exploration and development of oil and gas reserves in the north-west of WA with an excellent environmental record, while providing revenue to State and Commonwealth governments, returns to shareholders, jobs and support to local communities. Titles for oil and gas exploration are released based on commitments to explore with the aim of uncovering and developing resources. It is under the petroleum title lease agreement that Woodside has determined the potential to develop the hydrocarbon fields for which acceptance of this EP is sought under the Environment Regulations.

Woodside has established a number of research projects in order to understand the marine environments in which facilities are operated, notably in the Exmouth Region and the Kimberley Region, including Rankin Bank, Glomar Shoal, Enfield Canyon and Scott Reef. Where scientific data does not exist, Woodside assumes a pristine natural environment exists and therefore implements all practicable steps to prevent damage. Woodside's corporate values require consideration of the environment and communities when making decisions.

Woodside looks after the communities and environments in which it operates. Risks are inherent in petroleum activities; however, through sound management, systematic application of policies, standards, procedures and processes, Woodside considers potential impact is slight, short term and discharge of PW is acceptable.

Internal Context

The Petroleum Activities Program is consistent with Woodside corporate policies, standards, procedures, processes and training requirements as outlined in the Demonstration of ALARP (above) and EPOs (below), including:

- Woodside Health, Safety, Environment and Quality Policy (Appendix A)
- Woodside Risk Management Policy (Appendix A)
- Woodside Environmental Performance Procedure (which specifies maximum mixing zones and minimum sampling requirements).

Given that an approved mixing zone has been established at 720 m, the proposed limits of acceptable change meet the requirements of the Environmental Performance Procedure.

Woodside corporate values include working sustainably with respect to the environment and communities in which it operates, listening to internal and external stakeholders, and considering HSE when making decisions. Stakeholder consultation, outlined below, was undertaken prior to the Petroleum Activities Program.

External Context

Woodside recognises that its licence to operate from a regulator and societal perspective is based on historical performance, complying with appropriate policies, standards and procedures, and understanding the expectations of external stakeholders. External stakeholder consultation (Section 5) was undertaken prior to the Petroleum Activities Program and stakeholder feedback (Appendix F) was incorporated into this EP where appropriate.

Woodside believes that providing PW monitoring and control measures that are commensurate with the risk rating, location and sensitivity of the receiving environment (including social and aesthetic values), any societal concerns are addressed to an acceptable level.

In addition, the Petroleum Activities Program is consistent with the objectives in the Ningaloo management plans (Management Plan for Ningaloo Marine Park and Muiron Islands Marine Management Areas, Ningaloo Marine Park Management Plan). Considerations regarding water quality, coral, shoreline and intertidal, macroalgal, seagrass, mangroves, seabirds and social and economic values are consistent with these management plans.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 5 No impact to ecosystem integrity from PW outside the approved mixing zone boundary.	**C 4.1** Refer to Section 6.6.4	**PS 4.1** Refer to Section 6.6.4	**MC 4.1.1** Refer to Section 6.6.4
	C 5.1 Monitor and manage OIW concentrations in accordance with PARCOM 1997/16 Annex 3 methodology. • Limiting average PW OIW to less than 30 mg/L (over a rolling 24-hour period).	**PS 5.1** OIW discharge is limited to a 30 mg/L concentration over a 24-hour rolling average.	**MC 5.1.1** Records demonstrate OIW rolling average limits are not exceeded.
	C 5.2 Inboard off-specification PW to maintain OIW concentrations below 30 mg/L.		
	C 5.3 Implement the Monitoring and Management Framework for PW including: • monitoring of PW discharge volume • chemical characterisation • WET testing.	**PS 5.3** No potential to impact ecosystem integrity from PW outside acceptable limits of change. The acceptable limit of change is no impacts from PW beyond the approved mixing zone.	**MC 5.3.1** Records show routine monitoring has been conducted as per Table 6-12. Further investigations have identified no potential to impact ecosystem integrity from PW outside the acceptable limits.
	C 5.4 Online monitoring and/or procedural controls in place to monitor and control PW OIW concentrations and prevent discharge of PW with high OIW concentrations. Process performance monitored by OIW concentration analyser. Conduct manual sampling on a 6-hourly basis if online analyser is unavailable, where safe and practicable to do so.	**PS 5.4 (a)** Instrumentation integrity is managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE Technical Performance Standard(s) P31 – Environmental Emissions Monitoring and Controls, which: • provides means of detecting environmental releases, emissions and discharges to prevent MEEs from manifesting over time, and/or assure compliance monitoring and reporting equipment as required. • ensure monitoring data is available to control PW discharge volume	**MC 5.4.1 (a)** Records demonstrate implementation of SCE Technical Performance Standard(s) and SCE Management Procedure. **MC 5.4.1 (b)** Records demonstrate manual sampling and calibration is undertaken as appropriate.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		and OIW concentrations • prevent discharge of PW with high OIW concentrations. **PS 5.4 (b)** If the OIW analyser is offline, manual sampling is undertaken when safe and practicable to do so. Six-hourly samples are taken in accordance with the Okha's sampling requirements	
	C 5.5 The online analyser is calibrated with a manual sample analyser in accordance with Laboratory Procedure AN-M-140.	**PS 5.5** Complete calibrations of online analyser and manual OIW sampling equipment in accordance with Laboratory Procedure.	**MC 5.5.1** Refer to MC 5.4.1 (b)

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

Context	
Process Description – Section 3.6.2 Facility Utility Systems – Section 3.6.8 Facility Operations – Section 3.6.9	Physical Environment – Section 4.4 Biological Environment – Section 4.5

Impact Evaluation Summary

Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***							
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact		Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Discharge of sewage, greywater and putrescible waste from FPSO and vessels to the marine environment.	-	-	X	-	X	-	-	A	F	Cumulative E	-	-	LCS GP PJ	Broadly Acceptable	EPO 6
Discharge of deck water from FPSO and bilge water from vessels to the marine environment.	-	-	X	-	X	-	-	A	F		-	-			
Discharge of brine from vessels and FPSO to the marine environment.	-	-	X	-	X	-	-	A	F		-	-			
Discharge of cooling water from FPSO and vessels to the marine environment.	-	-	X	-	X	-	-	A	F		-	-			

Description of Source of Impact

Sewage, Putrescible Waste and Greywater

Sewage and greywater are treated onboard the FPSO by a biological sewage treatment plant that includes maceration, biological treatment and disinfection. The sewage treatment plant onboard the FPSO is capable of handling inputs from up to 80 people, which is adequate for routine and non-routine personnel levels onboard the FPSO. Sewage treatment on facility support and subsea vessels varies. Treatment systems may require routine maintenance or repair during operations, which may necessitate infrequent, short periods in which sewage is directly discharged overboard.

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

The volume of sewage, greywater and putrescible waste generated is estimated to be ~6 m^3 per day (based on an average volume of 75 L/person/day). The actual volume of discharge varies depending on personnel levels on the

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FPSO and vessels. Treated sewage and greywater discharge from the FPSO is directly to the sea via the hull discharge line below the sea surface. Discharge locations from vessels may vary; however, discharges are typically at or near the water surface.

Drains system

Operational non-process discharges, process maintenance drainage and flushing discharges, washdown water and potential spills are contained in the non-hazardous and hazardous open drain systems onboard the FPSO. These systems drain to the slops tank for treatment (as described in Section 3.6.4) before being discharged overboard. Machinery space bilges on the FPSO also drain to the slops tank. The maintenance drain system leads to the rundown and blanket gas headers and collects spills and maintenance discharges from the compressor scrubbers and separators.

Chemicals used on the FPSO may be introduced to drains system, including:

- deck washdown, maintenance drainage of treated water systems (e.g. cooling medium), and other cleaning/flushing activities;
- mandatory annual testing of the active fire deluge and foam system for safety requirements
- marine growth treatment of drain system.

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

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

Brine

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

Seawater Systems (including Cooling Water)

The seawater systems on the FPSO are routinely used for process and machinery cooling; discharges are returned to the sea via the seawater disposal system or via marine sea chests for the vessel cooling system. Seawater used for cooling uses hypochlorite generation to inhibit marine growth. The average discharge rates of sea water from the topsides cooling system and hull seawater cooling systems are ~47,400 m^3/day and 9,600 m^3/day respectively. The maximum seawater discharge temperature from both systems is 60° C.

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Impact Assessment
Sewage, Putrescible Waste and Greywater The main environmental impact associated with ocean disposal of sewage, greywater and putrescible waste is eutrophication. Eutrophication occurs when the addition of nutrients, such as nitrates and phosphates, causes adverse changes to the ecosystem, such as oxygen depletion and phytoplankton blooms No significant impacts from the planned (routine and non-routine) discharges to the marine environment are anticipated given the minor quantities involved, the expected localised mixing zone, and high level of dilution into the open water marine environment of the Operational Area. Although the NWS Province 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 from vessels (approximately 0.075 m^3 a person per day) is not significant compared to the daily turnover of nutrients in the area. Furthermore, vessels are typically moving when in the Operational Area, which facilitates the mixing of sewage, putrescible wastes and greywater from vessels. This assessment is supported by infield monitoring undertaken around the GWA platform. A facility with typically more personnel onboard will discharge larger volumes of sewage and putrescible waste than a vessel. Monitoring at GWA indicated there was no detectable decrease in oxygen saturation, nutrients or increase in oxygen demand at the GWA platform (BMT Oceanica 2015b). In addition, monitoring of sewage discharge demonstrated that a 10 m^3 sewage discharge reduces to ~1% of its original concentration within 50 m of the discharge location (Woodside 2008). The impact of nutrients associated with the discharge of sewage, greywater and putrescible waste is considered to have a localised impact, with no lasting effect due to the small mass and the assimilative capacity of the receiving environment. ***Drains System*** The slops tank receives inputs from a range of sources, including Okha FPSO drain systems. Slops tank water may contain small quantities of dissolved and residual hydrocarbons, and other chemicals such as detergents and cleaning agents. The impacts of discharge from the slops tank can include a decline in water quality and may directly affect marine organisms, with impacts varying depending on volumes discharged and the type of contaminants. Impacts from the discharge of the slops tank are assessed as being highly localised, with no lasting effect due to the rapid dilution and dispersion. Water-foaming agents used in firefighting foam may be harmful to aquatic organisms in freshwater environments like ponds and streams. This effect of this chemical release is greatly diminished in the offshore environment (due to wave and wind action) and does not present the same risks to pelagic fish and other marine life as it is rapidly dispersed. Nevertheless, the planned release of these materials is restricted to testing activities to ensure safe and effective operation of the system in an emergency. Bilge and deck drainage from vessels are expected to mix rapidly in the marine environment upon discharge. Given the rapid mixing, relatively small typical bilge and deck drainage water volumes, and expected low levels of potential contaminants, impacts from bilge and deck drainage water from vessels and the facility are assessed as highly localised with no lasting effect. ***Brine*** Brine plumes may result in osmotic stress to marine biota that rely on gills or diffusion across cell membranes to maintain osmotic pressure within cells. Mobile fauna such as fish may move away from the brine plume; hence impacts are restricted to planktonic and sessile organisms. Once discharged into the marine environment, the brine plume is expected to sink due to its relatively high density. Sinking of the plume will facilitate turbulent mixing, as will surface currents and waves. Recent water quality monitoring at the Okha FPSO indicated the brine plume mixed rapidly once released and was not readily detectable within 50 m of the discharge location (BMT Oceanica 2015). On this basis, the RO brine plume is expected to mix rapidly. Impacts from RO brine discharge will have no lasting effects on the environment and are highly localised to the discharge location. ***Cooling Water*** The impacts of cooling water can include a decline in water quality and may directly affect marine organisms due to temperature changes, with impacts varying depending on volumes, temperature and type of contaminants. Temperature change from cooling water may affect open-water receptors (fish and plankton populations). Elevated seawater temperatures may cause a variety of effects on both fish and plankton, ranging from behavioural response (including attraction and avoidance behaviour) and minor stress for prolonged exposure. Fish are unlikely to be impacted by the elevated temperatures other than through behavioural changes (avoidance and attraction). While impacts to plankton may include mortality, with the rapid turnover of plankton communities and mixing of adjacent populations, populations are expected to recover rapidly once discharge ceases. Monitoring in the mixing zone around a similar FPSO (the NY FPSO),could not detect elevated temperatures (SKM, 2010), indicating that temperatures returned to ambient within 10 m of the discharge point. Given the Okha FPSO typically discharges 57,000 m^3/day compared to the 136,000 m^3/day discharged by NY, temperature elevation is

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expected to be undetectable within 10 m of the discharge point. No significant impacts from the planned discharges to environmental receptors are anticipated because of the localised mixing zone and high level of dilution into the open water marine environment.

Sodium hypochlorite is used in the cooling system to control biofouling, and is expected to readily dissociate and break down once discharged. Cooling water from the Okha FPSO may contain small quantities of total residual chlorine (TRC). Okha's cooling water is dosed at 2 ppm TRC; once through the system and discharged, it is expected this will be reduced to <1 ppm TRC.

Modelling of the TRC was undertaken for NRC (SKM 2008) at TRC concentration of 1 ppm and a higher discharge flow rate. In all scenarios, the modelled concentrations were below the PNEC for acute and chronic effects at 200 m distance from the discharge. The modelling report also states that discharged TRC would need to be 2.7 ppm before the acute or chronic PNEC is not reached at 200 m from the discharge source. Therefore, discharges are well below the 2.7 ppm within a 200 m mixing zone. Impacts from cooling water from the Okha FPSO are assessed as being highly localised and short-lasting and are anticipated to have no lasting effects on the environment.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*** [14]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Ohka FPSO and support vessels compliant with: • Marine Order 91 (Marine pollution prevention – oil) • Marine Order 95 (Marine pollution prevention – garbage) • Marine Order 96 (Marine pollution prevention – sewage).	F: Yes. CS: Minimal cost. Standard Practice.	Marine Orders required under Australian regulations; implementation is standard practice for commercial vessels as applicable to vessel size, type and class. Marine Orders 91, 95 and 96 reduce the potential impact of marine wastewater discharges on water quality.	Controls based on legislative requirements – must be adopted.	Yes **C 6.1**
Good Practice				
Chemical Selection and Assessment Environment Guideline: • Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected – no further control required. • If chemicals with a different OCNS rating, sub warning or non–OCNS-rated chemicals are required, chemicals will be assessed in accordance with the procedure prior to use.	F: Yes. Woodside routinely implements a chemical selection process at the Okha FPSO, which is based on OCNS. CS: Minimal. The OCNS is widely used throughout the industry and chemical suppliers are aware of the requirements of the scheme.	Selection and assessment of chemicals in accordance with the Woodside process reduces environmental impacts associated with planned chemical discharge.	Woodside's chemical selection process is used to ensure fluids discharged meet Woodside's chemical environmental risk assessment standards while still providing the required technical capability.	Yes **C 4.1**

[14] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[14]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Putrescible waste macerated prior to overboard discharge to increase dispersion, thus reducing impact of discharge on water quality	F: Yes CS: Minimal cost. Standard practice.	Treating and macerating putrescible waste is standard industry practice, ensuring the substance disperses in the receiving environment with minimal effects to water quality.	Benefits outweigh cost sacrifice.	Yes **C 6.2**
Sewage will be macerated prior to overboard discharge to increase dispersion thus reducing impact of discharge on water quality.	F: Yes CS: Minimal cost. Standard practice.	Treating and macerating sewage is standard industry practice, ensuring the substance disperses in the receiving environment with minimal effects to water quality.	Benefits outweigh cost sacrifice	Yes **C 6.3**
Professional Judgement – Eliminate				
Storage, transporting and treating/disposing onshore of sewage, greywater, putrescible and bilge wastes	F: No. Would present additional safety and hygiene hazards resulting from the storage, loading and transport of the waste material. CS: Not considered – control not feasible.	Not considered –control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
Long-term transport of potable water from shore for Okha FPSO and vessels.	F: Yes. Potable water can be sourced from onshore water supplies. CS: Significant. The long-term costs and operational complexity associated with potable water bunkering outweigh the cost and negligible environmental footprint associated with offshore RO supply.	The potential environmental impact is ranked as having negligible effect; eliminating RO brine from the discharge would provide negligible environmental gain.	When considering the negligible impact from the discharge of RO brine, reliance on bunkering of potable water and incremental support vessel activities is grossly disproportionate to the environmental impact.	No
Professional Judgement – Engineered Solution				
Open hazardous drains systems integrity maintained, and oily water separator pump available to support hydrocarbon recovery from slops tank.	F: Yes CS: Minimal cost. Standard practice.	The open hazardous drain system will be maintained to support appropriate disposal of environmentally hazardous liquids	Benefit outweighs cost sacrifice	Yes **C 6.4**
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of discharge of sewage,				

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[14]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
putrescible waste, greywater, bilge water, drain water, cooling water and brine. As no reasonable additional/ alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement
The impact assessment has determined that, given the adopted controls, impacts from the discharge of sewage, putrescible waste, greywater, bilge water, drain water, cooling water and brine will have localised impacts with no lasting effects. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oilfield practice/industry best practice and meet legislative requirements under Marine Orders 91, 95 and 96. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of these discharges to a level that is broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 6 Limit water quality impacts to Slight (E) from routine and non-routine wastewater discharges during the Petroleum Activities Program.	**C 6.1** Support vessels comply with Marine Orders for safe vessel operations: • Marine Order 91 (Marine pollution prevention – oil) • Marine Order 95 (Marine pollution prevention – garbage) • Marine Order 96 (Marine pollution prevention – sewage).	**PS 6.1** Vessels contracted whose practices comply with Marine Orders as applicable to vessel size, type and class.	**MC 6.1.1** Marine verification records demonstrate compliance with standard maritime safety procedures (Marine Orders 91, 95 and 96).
	Refer to **C 4.1**	Refer to **PS 4.1**	Refer to **MC 4.3.1**
	C 6.2 Putrescible waste from Okha FPSO macerated prior to overboard discharge.	**PS 6.2** Putrescible wastes macerated (specified to <25 mm size) when discharged to sea.	**MC 6.2.1** Putrescible and sewage system maintenance records.
	C 6.3 Sewage system macerator maintained.	**PS 6.3** Sewage system macerator maintained as far as practicable.	
	C 6.4 Facility open hazardous drains systems integrity is maintained, and oily water separator pump is available to support hydrocarbon recovery from slops tank.	**PS 6.4** Integrity will be managed in accordance with SCE Management Procedure (Section 6.1.5.2) and SCE technical Performance Standard(s) to prevent environment risk related damage to SCEs for: • F22 – Open Hazardous Drains to: – prevent escalation of an incident following loss of containment, fire and/or explosion by removing or containing flammable liquid from hazardous areas – support appropriate containment and disposal of environmentally hazardous liquids to avoid damage to the environment. – oily water separator pump available to support hydrocarbon recovery from slops tank.	**MC 6.4.1** Records demonstrate implementation of SCE technical Performance Standard(s) and Safety Critical Element Management Procedure.

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

Context	
Process Description – Section 3.6.2 Facility Utility Systems – Section 3.6.8 Facility Operations – Section 3.6.9	Physical Environment – Section 4.4

Impact Evaluation Summary

Source of Impact	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
FPSO and vessel fuel combustion emissions, FPSO operational flaring and fugitive emissions.	-	-	-	X	-	-	-	A	E	-	-	LCS GP PJ	Broadly acceptable	EPO 7

Description of Source of Impact

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

Fuel Emissions: Internal Combustion Engines and Waste Incinerators

Consumption of fuel for power generation is the largest source of greenhouse gas emissions on the FPSO The turbines may run on fuel gas or diesel. Emergency diesel generators may also be used when required.

Diesel is used for emergency generators, cranes and backup fuel for the turbine generators. The main marine engines on the FPSO also use diesel fuel. Diesel usage on the facility (excluding support vessels) in 2018–2019 was 6,299 sm^3, the combustion of which equated to the emission 17,068 tonnes of CO_2 equivalents.

In 2018–2019, 31,674,085 Sm^3 of fuel gas was used, the combustion of which equated to the emission of 1,632,165 tonnes of CO_2 equivalents. The forecast annual emissions from fuel combustion on the FPSO was estimated using emissions factors (as per National Greenhouse and Energy Reporting Scheme [NGERS] and National Pollutant Inventory [NPI] Emission Estimation Techniques [EET]) and are presented in Table 6-14.

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

Table 6-14: Estimated annual emissions from fuel combustion (excluding support vessels) (based on financial year 2018–19)

Emission Type	Estimated annual emissions from fuel gas combustion (T)	Estimated annual emissions from diesel combustion (T)	Estimated total annual emissions from fuel combustion (T)
CO_2	1,628,047.97	16,995.58	59,078.70
CH_4	126.70	0.97	87.52
N_2O	3.19	0.16	2.20
Total CO_2e	1,632,165.60	17,068.53	61,923.23
NO_X	256.24	331.33	32.82

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SO_X	0.41	0.11	0.00

Operational Flaring

Gas is exported from the Okha FPSO, with some gas used onboard as fuel gas. Under normal operating conditions, there is no flaring (except for nitrogen purge gas). Flaring is used to dispose excess hydrocarbons if there is a large gas release that cannot be accommodated by the recovery system, during process upsets and well start-ups. Gas flaring has the potential to increase the volumes of greenhouse gases emitted to the atmosphere.

The release of hydrocarbon gas combustion products to the atmosphere by flaring is an essential practice, primarily for safety requirements. Operational flaring is not routine and comprises non-routine, non-operational flaring that may result from activities such as:

- planned shutdowns and emergency shutdown testing
- unplanned shutdowns and emergency shutdowns, production restarts, equipment outage/failures, subsea flowline depressurisation and well remediation activities.

The flaring volume is impacted by reliability of the compression system (LP compressor and HP compressor) and the recovery system. The flash gas compressor allows a reduction in flaring volumes. During flaring, the burnt gas generates mainly water vapour and CO_2.

It is estimated that ~21,881 T of gas are flared per year (Table 6-15). Overall the flare efficiency is expected to improve.

Flaring volumes vary because of production rates and non-routine activities, outages and shutdowns. The forecast annual atmospheric emissions from flaring have been estimated using the NPI EET.

Table 6-15: Estimated annual atmospheric emissions from flaring at the Okha FPSO

Component	Flaring (T)
Flared volume (T)	21,881.00
CO_2	59,078.70
CH_4	87.52
N_2O	2.20
Total CO_2e	61,923.23
NO_X	32.82
SO_X	0.00
CO	190.36

** 2019 actual*

Non-routine Venting of Process Hydrocarbons via Flare System

During normal operations, small vents of gas from topside modules are directed to vapour recovery compressors from the relevant flare scrubber. If the gas cannot be accommodated by the recovery system, flow to that recovery system stops and is redirected to the HP and LP flare systems. These systems are maintained to effectively combust hydrocarbons as a critical component for the safe operation of the FPSO. In the unlikely event that the flares are extinguished or unavailable (such as following a major shutdown prior to system ramp-up), the hydrocarbon gas discharged via the flare system may initially not be combusted during the period required to purge the flare system and re-establish flare ignition. This may result in the short-term (minutes) low-rate release of hydrocarbon gas to the atmosphere.

Cargo Tank Inert Gas Venting

The inert gas system supplies inert gas to maintain a positive pressure in the vapour space of cargo tanks to prevent the ingress of air if there is a trip and hydrocarbon gas blanketing is not available. Hydrocarbon vapour forms in the cargo tanks as volatile hydrocarbons evaporate from the stored crude oil. This vapour is displaced from the cargo tanks as they are filled and vented to the atmosphere. Maintaining inert gas in cargo tank vapour spaces is required for the safe operation of the facility.

Fugitive Emissions

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

Fugitive emissions are, by their nature, difficult to quantify. The normal approach, using the Australia National Greenhouse and Energy Reporting (Measurement) Determination 2008, as accepted by the NGERS, is to indirectly estimate the amount of emissions based on product throughput. As much of the safe operation of the FPSO relies on

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the effective containment of hydrocarbons, the volumes of routine and non-routine fugitive emissions are considered small. Using these estimation techniques, the Okha FPSO reported 1516.07 tonnes of CO_2 equivalents lost through fugitive emissions in 2018–2019. Discrete, relatively small volumes of packed gases and charged systems including refrigerant gases are used across the FPSO and vessels; these have potential for small volume leaks (typically <100 kg per isolatable inventory). Such gases are used in the HVAC and refrigerant systems on the FPSO and vessels.

Impact Assessment
Facility and vessel routine and non-routine emissions, predominantly routine fuel combustion and flaring, have the potential to result in localised, temporary reduction in air quality, generation of dark smoke, and contribution to greenhouse gas emissions. Potential impacts of emissions depend on the nature of the emissions, as well as the location and nature of the receiving environment. The incineration of wastes onboard support vessels and venting from cargo tanks are considered to result in no impact to air quality. Okha FPSO design (including the rapidly dispersive characteristics of the gas turbine exhausts, flare and other emissions), the estimated level of pollutants in the emissions, and the absence of elevated background ambient levels were considered in estimating the potential for interaction with human and environmental sensitivities. The Okha facility and Operational Area is in a remote offshore location, with no expected adverse interaction with populated areas or sensitive environmental receptors associated with air emissions. There is a foraging BIA for the wedge-tailed shearwater overlapping the Operational Area; as such, wedge-tailed shearwaters may occur near the facility airshed. The nearest potential seabird roosting habitat, the Montebello Islands, are ~105 km south-south-west of the Operational Area at the closest point (distance to nearest shoreline). Given the low numbers of individuals expected potentially within the Operational Area, combined with the highly dispersed nature of air emissions from the Petroleum Activities Program, no impacts to wedge-tailed shearwaters due to air emissions are anticipated. Potential impacts are expected to be slight, short-term, localised air quality changes, limited to the airshed local to the Okha FPSO. Air emission impacts are not expected to have direct or cumulative impacts on sensitive environmental receptors. Additionally, air quality around the Okha FPSO is maintained to provide a safe working environment for operational staff. The flare and potential black smoke resulting from emissions may impact visual amenity. The offshore location of the Okha FPSO is not visible from the nearest point of the mainland (~100 km from the Operational Area at the closest point). Hence, no impacts to visual amenity for residential communities are expected. Visual amenity impairment to tourism activities are not expected.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Vessel operations comply with Marine Order 97 (Marine pollution prevention – air pollution) to reduce atmospheric emissions associated with vessel operations.	F: Yes CS: Minimal cost. Standard practice	Marine Order 97 is required under Australian regulations; implementation is standard practice for commercial vessels as applicable to vessel size, type and class. Marine Order 97 reduces air pollution from vessels.	Control based on legislative requirements – must be adopted	Yes **C 7.1**
NGERS and NPI reporting including an estimation of greenhouse gas, energy and criteria pollutants.	F: Yes CS: Minimal cost. Standard practice	Control based on legislative requirement to provide the national reporting framework for the reporting and dissemination of	Control based on legislative requirements – must be adopted	Yes **C 7.2**

15 Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[15]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
		information related to emissions, hazardous wastes, greenhouse gas emissions, greenhouse gas projects, energy consumption and energy production to meet the objectives and desired outcomes of the legislation(s) such as: • the maintenance and improvement of air and water quality, minimisation of environmental impacts associated with hazardous wastes; and an improvement in the sustainable use of resources • act as the single framework to inform policy, meet reporting requirements, avoid duplication, and ensure that facility net greenhouse gas emissions are managed within applicable baselines.		
Good Practice				
Monitor estimate and report facility fuel and flare emissions (in accordance with NGERS/NPI) to inform optimisation management practices and minimise environmental impact of emissions.	F: Yes. Fuel and flared gas are potential product streams. As such, Woodside applies optimisation and opportunity management processes to identify and prioritise enhancement opportunities which includes improvements through energy efficiency, or reduced fuel and flare gas usage. To support	Minimises environmental impact of emission through ongoing review, governance and optimisation.	Control is a WMS requirement – must be adopted.	Yes **C 7.3**

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
	this, fuel and flared gas is monitored to compare against annual optimisation targets. CS: Minimal cost. Standard practice.			
Professional Judgement – Eliminate				
Eliminating flaring by venting uncombusted hydrocarbons.	F: No. Routine hydrocarbon venting is not considered good industry practice, as unburnt hydrocarbons pose potential for greater environment impact compared to combustion emissions. The ability to flare hydrocarbons is a key safety feature on the facility. Removing the ability to flare hydrocarbons may result in unacceptable safety risks on the Okha FPSO. CS: Not assessed, control not feasible.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Professional Judgement – Substitute				
None identified				
Professional Judgement – Engineered Solution				
Maintaining flare to maximise efficiency of combustion and minimise venting, incomplete combustion waste products and smoke emissions.	F: Yes. CS: Minimal cost. Standard Practice.	Flare tip integrity and ignition system functionality minimises potential for venting, incomplete combustion waste products and smoke emissions.	Control is a WMS requirement – must be adopted.	Yes **C 7.5**
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of Okha FPSO and vessel atmospheric emissions. As no reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, atmospheric emissions from Okha FPSO and support vessel operations represent a negligible impact to receptors that is unlikely to result in a potential impact greater than slight, localised impact to air quality. The controls adopted meet the legislative requirements and Woodside's relevant Operational Standards and Procedures. The potential impacts are considered broadly acceptable

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Demonstration of Acceptability
if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the described emissions to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria

Outcomes	*Controls*	*Standards*	*Measurement Criteria*
EPO 7 Limit air quality impacts to Localised (E) from Okha FPSO and vessel operations during the Petroleum Activities Program.	**C 7.1** Vessels operations compliant with Marine Order 97 (Marine pollution prevention – air pollution) to reduce atmospheric emissions associated with vessel operations.	**PS 7.1** Okha FPSO and vessels comply with Marine Order 97 as applicable to vessel size, type and class.	**MC 7.1.1** Marine verification records demonstrate compliance with standard maritime safety procedures (Marine Order 97).
	C 7.2 NGERS and NPI reporting including an estimation of greenhouse gas, energy and criteria pollutants.	**PS 7.2** Okha FPSO activity emissions reported annually in accordance with NGERS and NPI.	**MC 7.2.1** NGERs and NPI reporting records.
	C 7.3 Monitor estimate and report facility fuel and flare emissions (in accordance with NGERS/NPI) to inform optimisation management practices and minimise environmental impact of emissions.	**PS 7.3.1** Instrumentation integrity is managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE Technical Performance Standard(s) P31 – Environmental Emissions Monitoring and Controls, which: • provide means of detecting environmental releases, emissions and discharges to prevent MEEs from manifesting over time, and/or as required to assure compliance monitoring and reporting equipment.	**MC 7.3.1** Records demonstrate implementation of SCE Performance Standard(s) and Safety Critical Element Management Procedure.
		PS 7.3.2 Flare profiles tracked against optimisation targets.	**MC 7.3.2** Records demonstrate performance against annual flare profiles.
	C 7.5 Maintaining flare to maximise efficiency of combustion and minimise venting, incomplete combustion waste products and smoke emissions.	Refer to **PS 7.3.1**	Refer to **MC 7.3.1**

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6.6.8 Routine Light Emissions: Light Emissions from FPSO, Vessels Operations and Operational Flaring

Context		
Process Description – Section 3.6.2 Facility Utility Systems – Section 3.6.8 Facility Operations – Section 3.6.9	Biological Environment – Section 4.5	Stakeholder Consultation – Section 5

Impact Evaluation Summary

Source of Impact	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Light emissions from FPSO and vessels.	-	-	-	-	-	X	-	A	F	-	-	LCS GP PJ	Broadly Acceptable	N/A
Light emissions from FPSO during flaring.	-	-	-	-	-	X	-	A	F	-	-			

Description of Source of Impact

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

External lighting is located over the entire FPSO deck, as well as vessels, with most external lighting directed towards working areas such as the topsides of the FPSO, or the back deck of vessels. The top of the flare tower (the highest point of the facility) is ~98 m above sea level. External lighting on vessels is typically lower than the FPSO lights, with vessel lighting usually reduced to improve night vision of bridge crew.

The distance to the horizon at which components of the FPSO is directly visible can be estimated using this formula:

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

where 'horizon distance' is the distance to the horizon at sea level in kilometres, and 'height' is the height above sea level of the light source in metres. Using this formula, the approximate distance at which the flare tower top is visible at sea level is ~35 km from FPSO (based on flare tower height of 98 m above sea level).

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

Impact Assessment

Light emissions can affect fauna in two main ways:

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

Potential fauna at the FPSO are predominantly pelagic fish and zooplankton, with a low abundance of transient species such as marine turtles, whale sharks, birds and large whales transiting through. There are no known critical habitats within the Operational Area for EPBC listed species, although there are three BIAs that overlap it (listed in Section 4.5.2).

Seabirds

The risk associated with collision from seabirds attracted to the light is considered to be low, given there is no critical habitat for these species within the Operational Area. There is a foraging BIA for the wedge-tailed shearwater

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Impact Assessment
overlapping the Operational Area; as such, wedge-tailed shearwaters may occur within the Operational Area. The nearest potential seabird roosting habitat, the Montebello Islands, are ~105 km south-south-west of the Operational Area at the closest point (distance to the nearest shoreline). Foraging wedge-tailed shearwaters may be attracted to sources of light emission to feed upon fish drawn to the light; however, the species feeds predominantly during the day, in association with pelagic predators (Catry et al. 2009, Whittow 1997). Most foraging trips are short, with single-day foraging trips significantly more common than any other length trip, with birds returning to nesting/roosting sites between trips (Congdon et al. 2005). As such, the numbers of wedge-tailed shearwaters present in the Operational Area at night is expected to be low relative to numbers in the daylight hours, and any potential changes to behaviour would only affect a relatively low number of birds. Given the species' global distribution and primarily diurnal foraging behaviour, impacts to wedge-tailed shearwaters from artificial lighting are considered to be localised with no lasting effect. In a study of offshore oil facilities in the North Sea, Poot et al. (2008) observed that migrating seabirds can be attracted to the lights and flares of offshore oil facilities, particularly on cloudy nights and between midnight and dawn. Migratory shorebirds travelling the East Asian-Australasian Flyway may transit through the Operational Area in the vicinity of the Okha FPSO and vessels transiting to staging areas, before moving to the Australian mainland (south in the spring) or Indonesia (north in the autumn). It is possible that many migratory birds may also take advantage of ships and offshore facilities in the area to rest. The FPSO has been operational for a number of years, and in that time no large groups of birds have been observed. The environmental impact associated with seabirds attracted to the light, and hence diverted from their migratory pathway is considered to be localised with no lasting effect ***Marine Turtles – Hatchlings*** Light emissions reaching turtle nesting beaches are widely considered detrimental, owing to interference with important nocturnal activities including choice of nesting sites and orientation/navigation to the sea by post-nesting females and hatchlings (Lorne and Salmon 2007, Salmon 2003, Tuxbury and Salmon 2005). Hatchling turtles use light as a visual cue to orientate themselves towards the sea during the post-hatching dash after emerging from the nest, orientating themselves towards the relatively bright horizon above the sea and away from the relatively dark dunes (Salmon et al. 1995b, Salmon and Witherington 1995). Turtles disorientated by artificial lighting may take longer, or fail, to reach the sea, potentially resulting in increased mortality through dehydration, predation or exhaustion (Salmon and Witherington 1995). The nearest potential nesting site in relation to the Okha FPSO is the Dampier Archipelago, ~90 km from the FPSO. Lighting and the tip of the flare tower will not be visible from this potential nesting site. Given the nature of the light emitted from the Okha FPSO and vessels, and the distance to the nearest landfall (and nearest significant rookeries), artificial light from the FPSO and vessels is not expected to be directly visible to hatchling turtles; therefore, impacts to hatchling turtles emerging from nests are not credible. ***Marine Turtles – Adults*** Artificial lighting may affect the location where turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon et al. 1995a, 1995b, Salmon and Witherington 1995). Lighting that affects nesting adult turtles is typically from residential and industrial developments overlapping the coastline, rather than lighting offshore from nesting beaches. The Operational Area does not contain any known critical habitat for any species of marine turtle. The Goodwyn-6 suspended exploration well does overlap with the internesting BIA for flatback turtles, but artificial lighting is not installed—any lighting impacts would be limited to during IMMR activities. There is no published literature or physiological attributes of marine turtles that would suggest offshore lighting is a threat to internesting turtles (Pendoley 2017). Therefore, while it is acknowledged that marine turtles may be present in low densities in the Operational Area, impacts are expected to be localised with no lasting effect. ***Fishes*** Lighting from activities in the Operational Area may result in the localised aggregation of fish below the source of light. Note: Fish may also aggregate around the FPSO due to the habitat provided by the facility and subsea infrastructure. These aggregations of fish would be confined to a small area. Any long-term changes to fish species composition or abundance is highly unlikely.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[16]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
None Identified.				

[16] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[16]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Good Practice				
None identified.				
Professional Judgement – Eliminate				
No use of external lighting during Petroleum Activities Program.	F: No. Light management will be consistent with that required to provide a safe working environment onboard Okha FPSO and vessels. CS: Not considered – control not feasible.	Not considered – control not feasible	Not considered – control not feasible.	No
No flaring during Petroleum Activities Program	F: No. While not a routine activity, the ability to flare hydrocarbons is a safety critical requirement onboard the Okha FPSO. Note: Woodside is committed to reducing flaring, and has developed annual internal facility flare targets, against which progress is monitored. Refer to Section 6.6.7 for further information on flaring. CS: Not considered – control not feasible.	Not considered – control not feasible	Not considered – control not feasible.	No
Professional Judgement – Substitute				
Substitute external lighting with 'turtle friendly' light sources (reduced emissions in turtle visible spectrum)	F: Yes. Replacement of external lighting with turtle friendly lighting is technically feasible, although is not considered to be practicable. CS: Significant cost sacrifice. The retrofitting of all external lighting on Okha FPSO and all vessels would result in considerable cost and time expenditure. Considerable logistical effort to source enough inventory of the range of light types onboard Okha FPSO and vessels.	The potential environmental consequence is ranked as no lasting effect; substituting for turtle friendly lighting would provide negligible environmental gain given the location of the Okha FPSO relative to sensitive habitats. Light from the flare is the most visible source of artificial light from the facility – turtle friendly lighting has no effect on this light source.	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice for minimal environmental benefit. The cost/sacrifice outweighs the benefit gained.	No
Professional Judgement – Engineered Solution				

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[16]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the potential impacts and risks from ongoing routine light emissions from the Okha FPSO and vessels to be ALARP in its risk state. As no reasonable additional/alternative controls were identified that would further reduce the impacts without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, in its current state, routine light emissions from the Okha FPSO and vessels represent localised impacts to marine fauna, with no lasting effect. Further opportunities to reduce the impacts have been investigated above. The potential impacts are consistent with good oilfield practice/industry best practice and are considered broadly acceptable in their current state. Therefore, Woodside considers standard operations appropriate to manage the impacts of light emissions to a level that is broadly acceptable.

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6.7 Unplanned Activities (Accidents, Incidents, Emergency Situations)

6.7.1 Unplanned Hydrocarbon or Chemical Release: Hydrocarbon Release during Bunkering/Refuelling and Chemical Transfer, Storage and Use

Context		
Facility Utility Systems – Section 3.6.8 Facility Operations – Section 3.6.9 Hydrocarbon and Chemical Inventories and Selection – Section 3.9 Subsea Inspection, Monitoring, Maintenance and Repair Activities – Section 3.10	Physical Environment – Section 4.4 Biological Environment – Section 4.5	Stakeholder Consultation – Section 5

Risk Evaluation Summary														
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Accidental spill of hydrocarbons to the environment during bunkering/refuelling.	-	-	X	-	-	X	-	A	D	2	M	LCS GP	Broadly acceptable	EPO 8
Accidental discharge of chemicals (including subsea control fluid) to the marine environment from storage, use or transfer.	-	-	X	-	-	X	-	A	E	4	M			

Description of Source of Risk

Diesel Bunkering/Refuelling

Diesel fuel is transferred to the FPSO by bunkering. Two key scenarios for the loss of containment of diesel during bunkering operations were identified:

- partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues, could spill diesel to the deck and/or into the marine environment. This would be <550 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break and complete loss of hose volume)
- partial or total failure of a bulk transfer hose or fittings during bunkering or refuelling, combined with a failure in procedure to shut off fuel pumps, for a period of up to five minutes, results in ~11 m^3 diesel loss to the deck and/or into the marine environment.

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

The primary diesel storage location onboard the FPSO and support vessels is dedicated bunker tanks within vessel hulls. Quantities of diesel stored topside are limited to day tanks (6 m^3), with all additional stored diesel located below the main deck or within the hull of the vessel (e.g. oil settling tanks, service and storage tanks and fuel tanks for equipment such as generators). Note: Equipment containing diesel may be used on deck (i.e. generators). Credible spills of diesel during use are typically small (<50 L) compared to potential releases during bunkering. Mechanisms are available to capture diesel from process/piping associated with bunkering and fuel transfers, which can be routed to the drainage system, where the spill can be contained.

Chemical Transfer, Use and Storage

Chemicals will be used during the Petroleum Activities Program for various purposes (refer to Section 3.9.2). Selection of chemicals is undertaken in accordance with the Woodside Chemical Selection and Assessment

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Environment Guideline (Woodside Doc No: WM0000MG9905057). Spills of chemicals (including non-process hydrocarbons) can originate from equipment on the FPSO, support vessel decks or subsea (refer to Section 6.6.4 for an assessment of the impacts of planned chemical discharges).

Operational process chemicals on the FPSO are typically stored in dedicated vessels. The chemical stored in the largest volume on Okha is emulsion breaker, which is an operational process chemical stored in bulk (~13 m^3).

Operational non-process chemicals and maintenance chemicals present on the FPSO and support vessels are generally held in low quantities. Subsea support vessels undertaking IMMR activities may also store quantities of chemicals for subsea use. Accidental releases of small quantities of subsea chemicals from topsides may occur (e.g. deck spills). Operational experience indicates potential volumes of such spills is small (<20 L). Subsea chemical use is described in Section 3.10.1.6. Unplanned losses of subsea chemicals may occur from the subsea infrastructure. Up to 400 L/day for 5 to 22 days is the worst-case unplanned subsea control fluid release rate experienced due to a control line failure subsea.

Releases from equipment may occur from the failure of hydraulic hoses or minor leaks from process components, or spills during refuelling of equipment, which can either be located inside or outside bunded/drained areas.

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

Hydrocarbon Characteristics

Refer to Section 6.8.9.for a description of the characteristics of diesel, including detail on the predicted fate and weathering of a spill to the marine environment. Note: The diesel scenario considered in Section 6.8.9. is significantly larger than the volumes considered here due to bunkering and topside storage volumes.

Consequence Assessment

Diesel

Hydrocarbon spill modelling for a 105 m^3 release of diesel due to loss of marine vessel separation (MEE-07) is discussed in Section 6.8.9. The results of this modelling can be considered to be a very conservative estimate of the worst-case diesel bunkering loss of containment of 11 m^3. The results of a 105 m^3 diesel release indicate very low probabilities of contact with sensitive receptors for floating, entrained and dissolved hydrocarbons. The impact associated with a 11 m^3 diesel bunkering release are assumed to be substantially smaller than those indicated for a 105 m^3 diesel release.

Given the low viscosity of diesel, along with the high portion of volatile components, a spill of up to 11 m^3 of diesel during transfer, storage or use would spread and weather rapidly. Environmental receptors at risk would be restricted to those in the vicinity (<1 km from the release location) and may include:

- marine fauna, particularly fauna associated with the sea surface (e.g. seabirds, air-breathing vertebrates)
- plankton.

Given the relatively small worst-case credible release volume, the non-persistent nature of diesel and the low sensitivity of the receiving environment within the Operational Area (i.e. offshore open-water environment [refer to Section 4]), potential impacts are expected to be short term (<1 year) and confined to <1 km from the release location. Such impacts may include:

- localised decrease in water quality
- acute toxic effects to planktonic organisms in the immediate area of the spill.

Impacts to plankton may include acute toxicity resulting in mortality of planktonic organisms. Given the rapid turnover of plankton communities, these impacts will be short-lived (hours to days). Impacts to fish are expected to be minor and short term. Impacts to larger fauna such as cetaceans and marine turtles are expected to be light fouling, potentially resulting in irritation of sensitive membranes such as the eyes, mouth and digestive system (Helm et al. 2015). Mortality of larger fauna is not expected to occur. No impacts to ecosystem function are expected.

Minor short-term impacts may occur to other marine users (e.g. commercial fisheries); however, as the worst-case diesel spill is only 11 m^3, and there is already no fishing within the Operational Area and minimal fishing activity within 1 km of the Okha FPSO it is unlikely there would be any significant impact to commercial fishers.

As a result of this assessment, the highest potential consequence of a diesel spill from a bunkering incident has been defined as Minor and short-term and the likelihood as Unlikely (2), resulting in an overall Moderate risk following the implementation of identified controls.

Chemicals

The chemical stored in the largest volume on the Okha FPSO is an emulsion breaker, which is not planned for discharge. A maximum credible spill of emulsion breaker (or other operational chemical) is expected to mix with the offshore receiving environment, with localised decrease in water quality near the release. Potential impacts on plankton and fish in the immediate vicinity of the spill may occur with no lasting effect. No impacts to sediment quality

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Consequence Assessment
are anticipated due to water depths (~75 to 130 m) and the open ocean mixing environment. Given the localised nature of impacts, distance from sensitive receptors and relatively low credible release volumes, no impacts to ecosystem function are expected from topsides releases. Accidental releases of chemicals from subsea will decrease the water quality in the immediate area of the release. Once released into a low-sensitivity receiving environment, subsea control fluids are expected to mix rapidly and dilute in the water column. There is potential for slight, localised decrease in water quality at release locations and potential impacts on marine biota. Within the mixing zone, impacts to pelagic fish are expected to be limited to avoidance of the localised area of the discharge and short-term, localised decline in planktonic organisms in the immediate vicinity of the discharge plume. Some components of subsea control fluid take longer to biodegrade. These components make up ~0.35% of the total volume. Therefore, for a release at 400 L/day, ~1.3 L may be present in the sediment after 28 days. This would be distributed over the area of the release. Given the frequency and volumes of releases, impacts to sediments are likely to be highly localised. Sediments in the Operational Area are expected to be broadly consistent with those in the NWS Province, as described in Section 4.4.4, with filter feeders such as sponges, ascidians, soft corals and gorgonians associated with areas hard substrate. The only areas of hard substrate expected in the vicinity are artificial habitat associated with subsea infrastructure. Subsea control fluid does not contain any components that are both bioaccumulative and non-biodegradable, therefore chronic effects to ecosystems are not expected due to the localised nature of discharge plumes and potential for sediment quality impacts. As a result of this assessment, the highest potential consequence of an accidental discharge of chemicals to the marine environment has been defined as Slight and short-term and the likelihood as Likely (4), resulting in an overall Moderate risk following the implementation of identified controls.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[17]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Support vessels compliant with Marine Order 91 (Marine pollution prevention – oil) for safe vessel operations.	F: Yes. CS: Minimal cost. Standard practice.	Marine Order 91 is required under Australian regulations; implementation is standard practice for commercial vessels as applicable to vessel size, type and class. Compliance with Marine Order 91 reduces the risk of accidental hydrocarbon release during transfer	Control based on legislative requirement – must be adopted.	Yes **C 8.1**
Good Practice				
Chemical Selection and Assessment Environment Guideline: • Where Gold/Silver/E/D OCNS rating (and no OCNS substitution or product warning), chemicals are selected, no further control required.	F: Yes. Woodside routinely implements a chemical selection process at the Okha FPSO, which is based on OCNS. CS: Minimal. The OCNS is widely used throughout the industry, and chemical suppliers	Selection and assessment of chemicals in accordance with the Woodside process reduces environmental impacts associated with planned chemical discharge.	Woodside's chemical selection process is used to ensure fluids discharged meet Woodside's chemical environmental risk assessment standards while still providing the required technical capability.	Yes **C 4.1**

[17] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[17]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
• If chemicals with a different OCNS rating, sub warning or non–OCNS-rated chemicals are required, chemicals are assessed in accordance with the procedure prior to use.	are aware of the requirements of the scheme.		Benefits outweigh cost sacrifice.	
Limit volume of subsea control fluid discharged to the marine environment through monitoring subsea control fluid use, investigating material discrepancies, and using subsea control fluid with dye marker to help identify potential integrity failures.	F: Yes. The use of subsea control fluid is monitored to maintain adequate fluid in the system. CS: Minimal cost.	Limits the volumes of subsea control fluid discharge to the marine environment.	Benefit outweighs cost sacrifice.	Yes **C 4.3**
Increased inspection of the subsea system to prevent unplanned discharges of subsea control fluid.	F: Yes. Inspection frequency is currently risk based. CS: Cost and duration of full field inspection.	Minimal benefit as failures are typically catastrophic. Most effective means to identify unplanned releases is via consumption monitoring (in place)	Grossly disproportionate. Implementation of the control requires considerable cost sacrifice and provides minimal environmental benefit. The cost/sacrifice outweighs the benefit gained.	No
Diesel bunkering hoses will • have dry break couplings • be pressure-rated at purchase to reduce the risk of accidental hydrocarbon release during bunkering.	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of a hose failure.	Benefits outweigh cost sacrifice	Yes **C 8.2**
Implementation of bunkering procedures to reduce the risk of a hydrocarbon release as a result of a bunkering incident.	F: Yes. CS: Minimal cost. Standard practice.	Implements a procedure to outline the methods and requirements for undertaking safe bunkering. This reduces the likelihood of a bunkering incident.	Benefits outweigh cost sacrifice	Yes **C 8.3**
Safely storing chemicals and diesel to prevent the release to the marine environment.	F: Yes. CS: Minimal cost. Standard practice.	Reduces risk of unplanned chemical/diesel release.	Benefits outweigh cost sacrifice.	Yes **C 8.4**

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[17]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Incident reports are raised for unplanned releases within event reporting system.	F: Yes. CS: Minimal cost. Standard practice.	Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Control based on Woodside standard and regulatory requirements.	Yes **C 8.5**
Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.			
Professional Judgement – Eliminate				
None identified.				
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
FPSO drainage system in place to contain and dispose leaks and spills of hazardous liquids, to avoid harm to the environment.	F: Yes. The FPSO has been designed with an integral drains system that can be used to contain liquid spills in hazardous and non-hazardous areas. CS: Minimal. Inherent feature of FPSO design.	The drains system can be used to contain a spill before it reaches the environment.	Benefit outweighs cost sacrifice.	Yes **C 8.6**
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts of accidental spills of hydrocarbons or chemicals from bunkering/refuelling, storage, use and transfer. As no reasonable additional/alternative controls were identified that would further reduce the consequences and risks without grossly disproportionate sacrifice, the risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The consequence assessment has determined that, given the adopted controls, accidental spills during bunkering/refuelling, or spills from storage, transfer and use represent a moderate risk rating that is unlikely to result in a consequence greater than minor, short-term impacts. Further opportunities to reduce the risks have been investigated above. The adopted controls are considered good oilfield practice/industry best practice and meet requirements of Australian Marine Orders. The potential risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the risks of bunkering/refuelling, and storage, transfer and use to a level that is broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 8 Environmental risk posed by hydrocarbon or chemical spills limited to Moderate during bunkering, refuelling and chemical transfer, storage and use during the Petroleum Activities Program.	**C 8.1** Support vessels compliant with Marine Order 91 (Marine pollution prevention – oil) for safe vessel operations.	**PS 8.1** Support vessel practices comply with Marine Orders as applicable to vessel size, type and class (Marine Order 91).	**MC 8.1** Marine verification records demonstrate compliance with Marine Order 91.
	C 4.1 Refer to Section 6.6.4	**PS 4.1** Refer to Section 6.6.4.	**MC 4.1.1** Refer to Section 6.6.4.
	C 4.3 Refer to Section 6.6.4.	**PS 4.3** Refer to Section 6.6.4.	**MC 4.3.1** Refer to Section 6.6.4.
	C 8.2 Diesel bunkering hoses will: • have dry break couplings • be pressure-rated at purchase to reduce the risk of accidental hydrocarbon release during bunkering.	**PS 8.2** Diesel transfer hoses to have dry break couplings and pressure rating suitable for intended use.	**MC 8.2.1** Records demonstrate diesel transfer hoses are fitted with dry break couplings and are pressure-rated.
	C 8.3 Implementation of bunkering procedures to reduce the risk of a hydrocarbon release as a result of a bunkering incident.	**PS 8.3.1** Implement Diesel Fuel System – Loading Bunkers – Standard Operating Procedure (Woodside Doc No. EH0000MG0137.5001). Key requirements include: • Routine bunkering to be carried out when adequate lighting is available for spill detection unless following an activity-specific risk assessment approved by the Offshore Installation Manager (OIM). • Communications between the supply vessel and facility bunker station will be maintained during bunkering. • Hoses and connections to be visually checked during refuelling. • Tank levels will be monitored throughout bunkering. • Spill clean-up equipment will be available near the bunker station. • Bunkering hose inventory will be drained to the supply vessel before disconnection.	**MC 8.3a** Records demonstrate bunkering undertaken in accordance with facility and contractor bunkering procedures.
		PS 8.3.2 Vessels will have in place their own bunkering plans and checklists depending on the	**MC 8.3b** Marine verification records demonstrate vessel-specific bunkering plans

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		specifications of both the supplying and receiving vessel.	available and applied during bunkering operations.
	C 8.4 Chemicals will be stored safely to prevent the release to the marine environment.	**PS 8.4** Chemical/diesel storage areas for transportable containers on the FPSO will have adequate containment in place to contain an accidental chemical/diesel spill.	**MC 8.4** FPSO chemical/diesel storage areas for transportable containers provided with adequate bunding/containment.
	C 8.5 Incident reports are raised for unplanned releases within event reporting system.	**PS 8.5** • incident reports raised for unplanned releases • recordable incidents notified for unplanned liquid releases to sea of: – 80 L or more of hydrocarbons; or – 1000 L or more of environmentally hazardous chemical in any 48-hour period.	**MC 8.5** Records demonstrate incident reports raised for unplanned releases, and applicable recordable incident notifications completed.
	C8.6 Okha FPSO drainage system in place to contain and dispose leaks and spills of hazardous liquids.	**PS 8.6** Integrity will be managed in accordance with SCE Management Procedure (Section 6.1.5.2) and SCE technical Performance Standard(s) to prevent environment risk related damage to SCEs for: • F22 – Hazardous Open Drains and F23 – Non-hazardous Open Drains to together: – prevent escalation of an incident following loss of containment, fire and/or explosion by removing or containing flammable liquid from hazardous areas – support appropriate containment and disposal of environmentally hazardous liquids to avoid damage to the environment.	**MC 8.6**Records demonstrate implementation of SCE Performance Standard(s) and Safety Critical Element Management Procedure (F22 and F23).
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.7.2 Unplanned Discharges: Hazardous and Non-hazardous Waste Management

Context	
Operational Details – Section 3.6	Physical Environment – Section 4.4 Biological Environment – Section 4.5

Risk Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Incorrect disposal or accidental discharge of non-hazardous and hazardous waste to the marine environment.	-	X	X	-	-	X	-	A	E	2	M	LCS GP PJ	Broadly Acceptable	EPO 9

Description of Source of Risk
Non-hazardous and Hazardous Waste Normal operations on the FPSO and support vessels result in various hazardous and non-hazardous wastes. These materials could potentially impact the marine environment if incorrectly disposed or discharged in significant quantities. Non-hazardous wastes include domestic and industrial wastes, such as aluminium cans, bottles, paper and cardboard and scrap steel. Hazardous wastes include recovered solvents, excess or spent chemicals, oil-contaminated materials (e.g. sorbents, filters and rags), batteries and potentially material containing naturally occurring radioactive materials (NORMs). Monitoring is conducted to identify and manage waste containing NORMs in hydrocarbon-containing infrastructure. Sand and sludges may also be periodically generated during well clean-up operations, desanding and vessel maintenance. Waste materials generated on the FPSO (including hazardous wastes) are transported to shore for disposal or recycling by a licensed waste contractor unless approved for discharge to the environment.

Consequence Assessment
Non-hazardous and Hazardous Waste The potential impacts of non-hazardous and hazardous wastes accidentally discharged to the marine environment include direct pollution and contamination of the marine environment, potentially resulting in slight localised decreased water or sediment quality. Secondary impacts due to potential contact with individual marine fauna include entanglement or ingestion, which may lead to injury and/or death of individual animals. Based on the nature and scale of activities that may generate wastes, the location of the Operational Area, the types, size and frequency of wastes that could occur, and species present, the highest potential consequence for the temporary or permanent loss of hazardous or non-hazardous waste materials into the marine environment has been defined as Slight with short-term impacts, and the likelihood as Unlikely (2), resulting in an overall Moderate risk following the implementation of identified controls.

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[18]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Support vessels compliant with Marine Orders for safe vessel operations: • Marine Order 94 (Marine pollution prevention – packaged harmful substances) • Marine Order 95 (Marine pollution prevention – garbage).	F: Yes CS: Minimal cost. Standard practice.	Implementation of Marine Orders 94 and 95 reduces the likelihood of a harmful substance being released to the environment. Implementation is standard practice for commercial vessels as applicable to vessel size, type and class.	Controls based on legislative requirements – must be adopted.	Yes **C 9.1**
Good Practice				
Storage, handling and transport of wastes in accordance with the Waste Management Plan for Offshore Facilities.	F: Yes CS: Minimal cost. Standard practice.	Reduces the likelihood of a release of waste to the environment by providing guidance on storage, handling and transport of wastes.	Benefit outweighs cost sacrifice.	Yes **C 9.2**
If safe and practicable to do so, vessel, ROV or crane will be used to attempt recovery of material[19] environmentally hazardous or non-hazardous solid object/waste lost overboard.	F: Yes CS: Minimal cost. Standard practice.	Potentially reduces consequence by recovering object/waste container from the environment.	Benefit outweighs cost sacrifice	Yes **C 9.3**
Incident reports are raised for unplanned releases within event reporting system.	F: Yes CS: Minimal cost. Standard practice.	Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Control based on Woodside standard and regulatory requirements.	Yes **C 8.4**
Professional Judgement – Eliminate				
None identified.				
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of accidental discharge of non-hazardous and hazardous wastes. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

[18] Qualitative measure

[19] For this control/performance standard, 'material' is defined as unplanned releases of environmentally hazardous or non-hazardous solid object/waste events with an environmental concequence of >F.

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Demonstration of Acceptability
Acceptability Statement The consequence assessment has determined that, given the adopted controls, the accidental discharge of non-hazardous waste and hazardous waste represent a Moderate risk rating, and no lasting impacts to water quality, marine sediments and marine species are expected. These potential impacts are considered to have no lasting effect and are not considered to be significant. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oilfield practice/industry best practice and meet relevant Commonwealth and State regulatory requirements. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of accidental discharge of non-hazardous and hazardous waste to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 9 Environmental risk from hazardous and non-hazardous waste management limited to Moderate during the Petroleum Activities Program.	**C 9.1** Contract vessels compliant with Marine Orders for safe vessel operations: • Marine Order 94 (Marine pollution prevention – packaged harmful substances) • Marine Order 95 (Marine pollution prevention – garbage).	**PS 9.1** Vessels contracted whose practices comply with Marine Orders as applicable to vessel size, type and class.	**MC 9.1** Marine verification records demonstrate compliance with standard maritime safety procedures (Marine Orders 94 and 95).
	C 9.2 Implementation of Waste Management Plan for Offshore Facilities (W8000AH001).	**PS 9.2** Implementation of Waste Management Plan for Offshore Facilities (W8000AH001), including: • waste segregation and storage • records of all waste to be disposed, treated or recycled shall be maintained; records shall include (though are not limited to) quantity of waste, waste type and disposal/recycle location • waste streams shall be appropriately handled and managed according to their hazard and recyclability class • all non-putrescible waste (excludes all food, greywater or sewage waste) shall be transported and disposed of onshore.	**MC 9.2** Records demonstrate implementation of Waste Management Plan for Offshore Facilities (W8000AH001).
	C 9.4 If safe and practicable to do so, vessel, ROV or crane will be used to attempt recovery of	**PS 9.3** Material environmentally hazardous or non-hazardous solid waste object/container dropped to the marine environment will be recovered	**MC 9.3** Records detail the recovery attempt consideration and status of material environmentally hazardous or nonhazardous solid

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	material[20] environmentally hazardous or non-hazardous solid object/waste lost overboard.	where safe and practicable to do so, considering: • risk to personnel to retrieve object • whether the location of the object is in recoverable water depths • object's proximity to subsea infrastructure • ability to recover the object (i.e. nature of object, lifting equipment, ROV availability and suitable weather).	waste object/container lost to the marine environment.
	C 8.5 Refer to Section 6.7.1.	**PS 8.5** Refer to Section 6.7.1.	**MC 8.4** Refer to Section 6.7.1.

6.7.3 Physical Presence: Interactions with Marine Fauna

Context	
Facility Operations – Section 3.6.9	Species – Section 4.5.2

Risk Evaluation Summary														
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence/Impact	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Physical presence of vessels resulting in collision with marine fauna.	-	-	-	-	-	X	-	A	E	1	L	LCS GP PJ	Broadly Acceptable	EPO 10

Description of Source of Risk
The vessels operating in and around the Operational Area have the potential in interact with cetaceans and other protected marine fauna such as whale sharks and marine reptiles. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction), and mortality. The potential frequency and severity of impacts due to collisions vary due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth), and the type of marine fauna potentially present and their behaviours.

[20] For this control/performance standard, 'material' is defined as unplanned releases of environmentally hazardous or non-hazardous solid object/waste events with an environmental concequence of >F.

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Consequence Assessment
The likelihood of vessel–whale collision being lethal is influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Jensen and Silber 2004, List et al. 2001). Vanderlande and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from ~20% at 8.6 knots to ~80% at 15 knots. According to the data of Vanderlin and Taggart (2007), it is estimated that the risk is <10% at a speed of 4 knots. Vessel–whale collisions at this speed are uncommon and, based on reported data contained in the NOAA database, there are only two known instances of collisions when the vessel was travelling at <6 knots. Both of these were from whale-watching vessels that were deliberately placed among whales (Jensen and Silber 2004). Vessels undertaking activities within the Operational Area are likely to be travelling <8 knots; much of the time vessels are holding stationary. Therefore, the risk of a vessel collision with protected species resulting in death is inherently low. The Operational Area occurs near but does not overlap the humpback whale and pygmy blue whale migration BIAs (Section 4.5.2.5). Humpback whales may be abundant near the Operational Area during their seasonal migration period but are unlikely to traverse it. Analysis of underwater noise logger data indicated pygmy blue whales are present in waters off North West Cape between October to December (northbound migration) and April to August (southbound migration) (McCauley and Jenner 2010). Satellite tagging studies have shown pygmy blue whales migrating along the WA coast in water depths between 200 m and 1000 m, which does not include the depth range of the Operational Area (~75 to 130 m). Given the lack of overlap between the humpback whale and pygmy blue whale migration BIAs, and the consequent low likelihood of either species traversing the Operational Area, harmful interactions between vessels and whales during the activity are considered unlikely. Given the typical speeds of vessels within the Operational Area, the unlikely event of a collision between vessels and whales is not expected to result in mortality. Whale sharks are at risk from vessel strikes when feeding at the surface, or in shallow waters where there is limited opportunity to dive. Whale sharks may traverse offshore waters, including in the Operational Area, during their migrations to and from Ningaloo Reef, and 0.08% of the BIA for foraging whale sharks overlaps the Operational Area. Due to the small proportion of the foraging BIA overlapped by the Operational Area impacts to whale sharks are not expected, and their presence within the operational area would be transitory and of a short duration. There are no constraints (e.g. shallow water, shorelines) preventing whale sharks from moving away from vessels. The internesting buffer for flatback turtles BIA overlaps the Operational Area at the Goodwyn-6 suspended exploration well. During internesting turtles remain close to the nesting beach or rookery (DoEE 2017). Typically, internesting habitat is located immediately seaward of designated nesting habitat (DoEE 2017). Part of the Operational Area overlaps the flatback turtle 60 km internesting buffer zone (October–March); however, given the Operational Area is >70 km from the nearest nesting beach, internesting turtles are not anticipated to remain in the Operational Area for prolonged periods of time or in large numbers. The typical response from turtles on the surface to the presence of vessels is to dive (a potential ‘startle’ response), which decreases the risk of collisions (Hazel et al. 2007). As with cetaceans, the risk of collisions between turtles and vessels increases with vessel speed (Hazel et al. 2007). It is not deemed credible that vessel movement associated with the Petroleum Activities Program could have a significant impact on marine fauna populations given (1) the low presence of transiting individuals, (2) avoidance behaviour commonly displayed by whales, whale sharks and turtles, and (3) low operating speed of the activity support vessels in the Operational Areas (generally <8 knots or stationary, unless operating in an emergency). Activities are considered highly unlikely to result in a consequence greater than slight, short-term disruption to individuals or a small proportion of the population and no impact on critical habitat or fauna activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[21]***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans will be implemented to reduce the likelihood of collision with whales and dolphins.	F: Yes CS: Minimal cost. Standard practice.	Reductions in speed around protected fauna reduce the likelihood of collision.	Controls based on legislative requirements – must be adopted.	Yes **C 10.1**
Good Practice				

[21] Qualitative measure

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[21]	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Extend application of EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans to turtles and whale sharks.	F: Potentially, however turtles and whale sharks are hard to detect at sea (Operational Area water depth is ~75–130 m). Whale sharks and turtles may be more difficult to detect than whales, due to their size (turtles) and the absence of clearly visible surface behaviour (e.g. blows). Additionally, turtles typically dive in response to disturbance, therefore would not always be feasible to implement. CS: Minimal cost.	Given the expected low numbers of turtles and whale sharks within the Operational Area, interactions between vessels and turtles/whale sharks are considered to be highly unlikely, therefore adopting the control would provide low benefit.	Disproportionate. Interactions between vessels and turtles/whale sharks are considered to be highly unlikely, therefore adopting the control would provide low benefit given its low effectiveness.	No
Professional Judgement – Eliminate				
Do not use vessels.	F: No. No alternative to the use of vessels during the Petroleum Activities Program was identified. As vessels must be used to undertake the Petroleum Activities Program, there is no feasible means to eliminate the source of risk. CS: Not assessed, control not feasible.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Professional Judgement – Substitute				
None identified.				
Professional Judgement – Engineered Solution				
None identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the risk of vessel collision with marine fauna. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The risk assessment has determined that, given the adopted controls, vessel collision with marine fauna represents a Low risk rating that is expected to result in no lasting effect to fauna populations and no impact on critical habitat or activity. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oilfield practice/industry best practice and meet the requirements of Part 8 (Division 8.1) of the EPBC Regulations 2000. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of vessel collision with marine fauna to a level that is broadly acceptable.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 10 No mortality of cetaceans resulting from interactions with support vessels or FPSO.	**C 10.1** EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, which includes these measures[22]: • Vessels will not travel >6 knots within 300 m of a cetacean (caution zone) and not approach closer than 100 m from a whale. • Vessels will not approach closer than 100 m from a whale (with the exception of animals' bow riding). • If the cetacean shows signs of being disturbed, activity support vessels will immediately withdraw from the caution zone at a constant speed of <6 knots.	**PS 10.1** Vessels will comply with the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.05 and 8.06) Interacting with cetaceans to manage the risk of fauna collision.	**MC 10.1.1** Records demonstrate no breaches with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans and Woodside Marine Charterers Instructions.
			MC 10.1.2 Records demonstrate reporting cetacean ship strike incidents to the National Ship Strike Database (https://data.marinemammals.gov.au/report/shipstrike).

[22] For safety reasons, the specified distance requirements are not applied for a vessel holding station or with limited manoeuvrability e.g. loading, backloading, offloading, close standby cover for overside working and emergency situations.

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6.7.4 Physical Presence: Introduction of IMS

Context		
Facility Operations – Section 3.6.9	Biological Environment – Section 4.5	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
IMS in vessel ballast tanks or on vessels/submersible equipment.	-	-	-	-	X	X	X	A	E	1	L	LCS GP PJ	Broadly Acceptable	EPO 11

Description of Source of Risk

Vessels are potential vectors for the introduction of IMS to the Operational Area during the Petroleum Activities Program; these include:

- facility support vessels: typically sourced from Australian waters and generally considered to be low risk, these vessels are the most commonly used vessels in the Operational Area.
- offtake tankers: typically from international waters and generally considered to be low risk, these tankers may visit the Operational Area approximately every three weeks, with offtake frequency declining as production rates decline; offtake operations take ~36 hours to complete.
- subsea support vessels: may be sourced from Australia or overseas, depending on requirements and vessel availability.

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

IMS may be introduced to the Operational Area through:

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

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

The FPSO may require ballast water to operate safely when detached from the RTM. Ballast water taken on within the Operational Area (i.e. prior to detachment) is considered unlikely to host IMS due to the offshore location and deep water (~75 to 130 m water depth). When returning from beyond Australian waters, the FPSO routinely undertakes ballast water exchanges to achieve low-risk ballast water. Ballast water exchanges are not typically required by support or subsea vessels. All support and subsea vessels are required to have low-risk ballast water onboard prior to being contracted.

All vessels are inherently subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where they can find a good surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests). Biofouling organisms can become established in an area by releasing propagules (e.g. eggs, larvae), or by attaching to substrate after becoming detached from the host vessel.

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

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Consequence Assessment
IMS have historically been introduced and translocated around Australia by various human means including biofouling and ballast water. Species of concern are those that: • are not native to the region • are likely to survive and establish in the region • are able to spread by human-mediated or natural means. Species of concern vary from one region to another, depending on environmental factors such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities. Introducing IMS into the local marine environment may alter the ecosystem, as IMS have characteristics that make them superior (in a survival and/or reproductive sense) to indigenous species. They may prey upon local species that had previously not been subject to this kind of predation and therefore not have evolved protective measures against the attack; they may outcompete indigenous species for food, space or light; and can also interbreed with local species, creating hybrids such that the endemic species is lost. IMS have also proven economically damaging to areas where they have been introduced and established. Such impacts include direct damage to assets (fouling of vessel hulls and infrastructure) and depletion of commercially harvested marine life (e.g. shellfish stocks). IMS have proven particularly difficult to eradicate from areas, once established. If the introduction is captured early, eradication may be effective but is likely to be expensive, disruptive and, depending on the method of eradication, harmful to other local marine life. Despite the potential high consequence of the establishment of a marine pest within a high-value environment, like coastal or sheltered nearshore waters, the deep offshore open waters of the Operational Area are not conducive to the settlement and establishment of IMS (Geiling 2016), due to the lack of light or suitable habitat to sustain growth or survival. The Okha FPSO facility is located on the NWS, ~37 km west of Glomar Shoal in waters ~75–130 m deep. Most vessels used during the Petroleum Activities Program are typically sourced from Australia and are not considered high risk for IMS introduction. Given this, the likelihood of introducing/acquiring IMS during the Petroleum Activities Program is considered highly unlikely and considered manageable given the ballast water and biofouling controls that will be implemented.

Summary of Potential Impacts to Environment Value(s)
In support of Woodside's assessment of the impacts and risks of IMS introduction associated with the Petroleum Activities Program, Woodside conducted a risk and impact evaluation of the different aspects of marine pest translocation associated with the activity. The results of this assessment are presented in the table below. As a result of this assessment, Woodside has presented the highest potential consequence as Slight and short-term and the likelihood as Highly Unlikely (1), resulting in an overall Low risk following the implementation of identified controls.

IMS Introduction Aspect	Credibility of Introduction	Consequence of Introduction	Likelihood
Transfer of IMS from infected vessel to Operational Area, and establishment on the sea floor or subsea infrastructure.	**Not Credible** The deep offshore open waters of the Operational Area, away from shorelines and/or critical habitat, more than 58 nm from shore and in waters 75–130 m deep, are not conducive to settling and establishing IMS.		
Transfer of IMS from infected vessel to and subsequent establishment on the Okha FPSO.	**Credible** There is potential for the transfer of marine pests to occur.	Slight (E) – Environment Minor (D) – Reputation and Brand If IMS were to establish, this would potentially result in fouling of intakes (depending on the pest introduced), and likely result in the quarantine of the Okha FPSO until eradication could occur	Highly Unlikely (1) Interactions between the Okha FPSO and support vessels will be limited during the Petroleum Activities Program, with a 500 m PSZ being adhered to. Offtake tankers are considered to present a low IMS risk, do not directly contact the Okha FPSO and are within the

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

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Consequence Assessment			
	vessel is not considered credible (i.e. beyond the Woodside risk matrix). The Okha FPSO is in an offshore, open ocean, deep environment. Support vessels only spend short periods of time alongside the Okha FPSO (i.e. during backloading or bunkering activities). There is also no direct contact (i.e. they are not tied up alongside) during these activities. Note: Woodside has conducted marine vessel movements between the Okha FPSO and WA ports (such as Dampier) for a long time, and no IMS has been detected in these ports (DoF 2017).		

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
All vessels will undertake ballast water exchange or treat ballast water using an approved ballast water treatment method/system.	F: Yes CS: Minimal cost. Standard practice.	Reduction in the likelihood that ballast water will host IMS.	Controls based on legislative requirements under the Commonwealth *Biosecurity Act 2015* – must be adopted.	Yes **C 12.1**
Good Practice				
Woodside's IMS risk assessment process [23] will be applied to vessels undertaking the Petroleum Activities Program. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment	F: Yes. CS: Minimal cost. Good practice implemented across all Woodside Operations.	Reduction in the likelihood that a vessel will host IMS.	Benefits outweigh cost/sacrifice.	Yes **C 11.2**

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

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.				
Monitor the Okha FPSO facility for IMS.	F: Yes. Implementation of a survey is considered feasible for the Okha facility. CS: Significant. IMS inspection of in-water assets typically requires diver-based inspections to reliably detect IMS. This is a costly, time-consuming process that introduces a significant safety risk. Monetary cost of IMS survey for Okha facility sized infrastructure would be ~$500,000 AUD (based on historical surveys of FPSOs by Woodside) and costs of ROV to support survey.	Potential for reduction of consequence. If detected, IMS can be managed.	Disproportionate. Interactions between Okha facility and support/subsea vessels will be limited, and the vessels involved will have been managed through the implementation of Woodside's IMS Management Plan (IMSMP) (**C 11.2**) a verified process which provides Woodside confidence in the verification of EPO 12. Consequently, any additional benefit gained by implementing this control is considered disproportionate, given the controls already adopted (and noting already-incurred cost through implementation of the IMSMP [i.e. inspections and cleaning where risk warrants]) and the unlikely likelihood of a translocation event.	No
Professional Judgement – Eliminate				
Do not use vessels.	F: No. No alternative to the use of vessels during the Petroleum Activities Program was identified. As vessels must be used to undertake the Petroleum Activities Program, there is no feasible means to eliminate the source of risk.	Not assessed, control not feasible.	Not assessed, control not feasible.	No

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
	CS: Not assessed, control not feasible.			
Professional Judgement – Substitute				
Source vessels based in Australia only.	F: Yes. Support vessels are routinely sourced from Australia. However, depending on the nature of subsea IMMR activities, there may not be a suitable subsea support vessel within Australian waters. CS: Potential for significant cost and schedule impacts.	Reduction in the likelihood that a vessel will host IMS.	Disproportionate. The cost/sacrifice is grossly disproportionate to the benefit gained.	No
IMS inspection of all vessels.	F: Yes. Approach to inspect vessels is feasible. CS: Significant cost and schedule impacts. Thorough inspections require vessels to be removed from the sea (e.g. slipped or dry docked) and examined by an IMS expert. This process incurs significant financial and schedule sacrifices.	Reduction in the likelihood that a vessel will host IMS.	Disproportionate. The cost/sacrifice is grossly disproportionate to the benefit gained. Interactions between FPSO and support/subsea vessels will be limited, and the vessels involved will have been managed through the implementation of Woodside's IMSMP (**C 11.2**).	No
Inspection of Okha FPSO by IMS inspector prior to return from international sailaway.	F: Yes. Approach to inspect vessels is feasible. CS: Significant cost and schedule impacts. Thorough inspections require vessels to be removed from the sea (e.g. slipped or dry docked) and examined by an IMS inspector. This process incurs significant financial and schedule sacrifices.	Reduction in the likelihood that the FPSO would host IMS on return to Operational Area from international sailaway.	Although the inspection of all vessels associated with Okha FPSO operations is considered disproportionate (see the rejected control above), considering the implementation of Woodside's IMSMP (**C 11.2**), the inspection of only the Okha FPSO by an IMS inspector is considered appropriate given the added level of confidence it provides.	Yes **C 11.3**
Professional Judgement – Engineered Solution				
None identified.				

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Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***	***Benefit in Impact/Risk Reduction***	***Proportionality***	***Control Adopted***
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of IMS introduction and establishment. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The risk assessment has determined that, given the adopted controls, introduction of IMS represent a low risk rating that is highly unlikely to result in an environmental consequence greater than slight impact on marine communities within the Operational Area. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oilfield practice/industry best practice and meet Australian legislative requirements, including the Commonwealth *Biosecurity Act 2015*. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of IMS to an acceptable level.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 11 No introduction of IMS into the Operational Area as a result of the Petroleum Activities Program.	**C 11.1** Vessels will undertake ballast water exchange or treat ballast water using an approved ballast water treatment method/system.	**PS 11.1** Compliance with Australian Ballast Water Management Requirements (as defined under the Commonwealth *Biosecurity Act 2015*) (aligned with the International Convention for the Control and Management of Ships' Ballast Water and Sediments) to prevent the introduction of IMS.	**MC 11.1** Ballast water exchange records maintained by vessels which verify compliance against Ballast Water Management requirements.
	C 11.2 Woodside's IMS risk assessment process is applied to vessels undertaking the Petroleum Activities Program. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced.	**PS 11.2** Compliance with Woodside's IMSMP to minimise the risk of introducing IMS.	**MC 11.2.1** Records of IMS vessel risk assessments maintained for vessels, as required by the IMSMP.
			MC 11.2.2 Records maintained of management measures that have been implemented where identified through the IMS vessel risk assessment process.
	C 11.3 Inspection of Okha FPSO by IMS Inspector prior to return from international sailaway.	**PS 11.3** FPSO will be inspected by a trained IMS inspector prior to return from international sailaway and any additional management measures identified to reduce the	**MC 11.3** Records of IMS inspection of FPSO maintained.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		translocation risk of IMS implemented.	

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6.8 Unplanned Activities (Accidents, Incidents, Emergency Situations) – Major Environmental Events

The risks considered in this section have been identified as MEEs due to the potential for significant consequence. These sources of risk are subject to additional consideration in accordance with the process described in Section 2.7.

All MEEs presented are as a result of hydrocarbon loss of containment to the marine environment and atmosphere. The risk assessments have been informed using quantitative hydrocarbon spill modelling. An overview of the MEEs is provided in Section 6.8.2.

6.8.1 Quantitative Spill Risk Assessment Methodology

Quantitative hydrocarbon spill modelling was undertaken by RPS APASA, on behalf of Woodside, using a three-dimensional (3D) hydrocarbon spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program), which is designed to simulate the transport, spreading and weathering of specific hydrocarbon 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 credible 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 model simulates surface releases and uses the unique physical and chemical properties of a hydrocarbon type to calculate rates of evaporation and viscosity change, including the tendency to form oil in water emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact of hydrocarbons due to surface slicks (floating hydrocarbon) and exposure of organisms to entrained and dissolved aromatic hydrocarbons in the water column.

During each simulation, the SIMAP model records the location (by latitude, longitude and depth) of each of the particles (representing a given mass of hydrocarbons) on or in the water column, at regular time steps. For any particles that contact a shoreline, the model records the accumulation of hydrocarbon mass that arrives on each section of shoreline over time, less any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

The collective records from all simulations are then analysed by dividing the study region into a 3D grid. For surface hydrocarbons (floating oil), the sum of the mass in all hydrocarbon particles located within a grid cell, divided by the area of the cell, provides hydrocarbon concentration estimates in that grid cell at each model output time interval. For entrained and dissolved aromatic hydrocarbon particles, concentrations are calculated at each time step by summing the mass of particles within a grid cell and dividing by the volume of the grid cell. The process is also subject to the application of spreading filters that represent the expected mass distribution of each distinct particle. The concentrations of hydrocarbons calculated for each grid cell, at each time step, are then analysed to determine whether concentration estimates exceed defined threshold concentrations.

All hydrocarbon spill modelling assessments undertaken by RPS APASA undergo initial sensitivity modelling to determine appropriate time to add to the simulation after the cessation of the spill. The amount of time following the spill is based on the time required for the modelled concentrations to practically drop below threshold concentrations anywhere in the model domain in the test cases. This assessment is done by post-processing the sensitivity test results and analysing time-series of median and maximum concentrations in the water and on the surface.

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6.8.1.1 Hydrocarbon Characteristics

As part of the risk identification process, Woodside identified the range of credible hydrocarbon spill scenarios that may occur during the Petroleum Activities Program. These scenarios are considered in the risk assessments of MEEs (Sections 6.8.3 to 6.8.10) and unplanned hydrocarbon discharges are presented in Section 6.7.1. A summary of the characteristics of the hydrocarbons used as the basis for the modelling studies (including definition of contact thresholds) used to inform the assessment of MEEs is provided in Table 6-16.

Table 6-16: Characteristics of the hydrocarbon type used for modelling and ecotoxological studies

Hydrocarbon Type	**Density (g/cm³ at 15 °C)**	**Viscosity (cP at 20 °C)**	**Component**	**Volatile**	**Semi-volatile**	**Low volatility**	**Residual**	**Aromatics**
			Boiling point (BP)	***<180 °C***	***180 – 265 °C***	***265 – 380 °C***	***>380 °C***	***Of whole oil <380 °C***
			Carbon chain	***C4 to C10***	***C11 to C15***	***C16 to C20***	***>C20***	***C6+ (Benzene ring)***
Cossack light crude	0.7875	1.4	% total	52.2	20.5	12.0	15.3	14.5
			% aromatics	3.7	1.3	9.5	-	-
Diesel	0.829	4.0	-	6	34.6	54.4	5	-

Cossack Light Crude

Cossack light crude (API 48.1) contains a moderate proportion (15.3% by mass) of hydrocarbon compounds that will not evaporate at atmospheric temperatures. These compounds will persist in the marine environment.

The unweathered mixture has a dynamic viscosity of 1.40 cP. The pour point of the whole oil (-24 °C) ensures it will remain in a liquid state over the annual temperature range observed on the NWS.

The mixture is composed of hydrocarbons that have a wide range of BPs and volatilities at atmospheric temperatures, and which will begin to evaporate at different rates on exposure to the atmosphere. Evaporation rates will increase with temperature, but in general about 52.2% of the oil mass should evaporate within the first 12 hours (BP <180 °C), a further 20.5% should evaporate within the first 24 hours (BP >180 °C to <265 °C), and a further 12.0% should evaporate over several days (BP 265 °C to < 380 °C).

Selective evaporation of the lower BP components will lead to a shift in the physical properties of the remaining mixture, including an increase in the viscosity and pour point. Although removing volatile compounds through evaporation and dissolution will result in an increase in density of the remaining oil, the mixture is unlikely to solidify or sink as it weathers.

The whole oil has low asphaltene content (<0.05%), indicating a low propensity to take up water to form water-in-oil emulsion over the weathering cycle.

Soluble aromatic hydrocarbons contribute ~14.5% by mass of the whole oil, with a moderate proportion (7.4%) in the C4–C10 range of hydrocarbons. These compounds will evaporate rapidly, reducing the potential for dissolving a proportion of them into the water.

In terms of weathering, modelling indicates that a moderate proportion of Cossack light crude will tend to persist on the sea surface (15% after 7 days) during calm wind conditions, with negligible levels of entrainment (<0.5%) and around 75% of the spilled volume is expected to evaporate within the first 24 hours (Figure 6-4). For variable strength winds, modelling indicates that a higher percentage of Cossack light crude is likely to entrain and dissolve in the water column. Approximately 24 hours after the spill, ~24% of the oil mass is forecast to have entrained and a further 66% is

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forecast to have evaporated, leaving only a small percentage (~0.5%) of the oil floating on the sea surface (Figure 6-5).

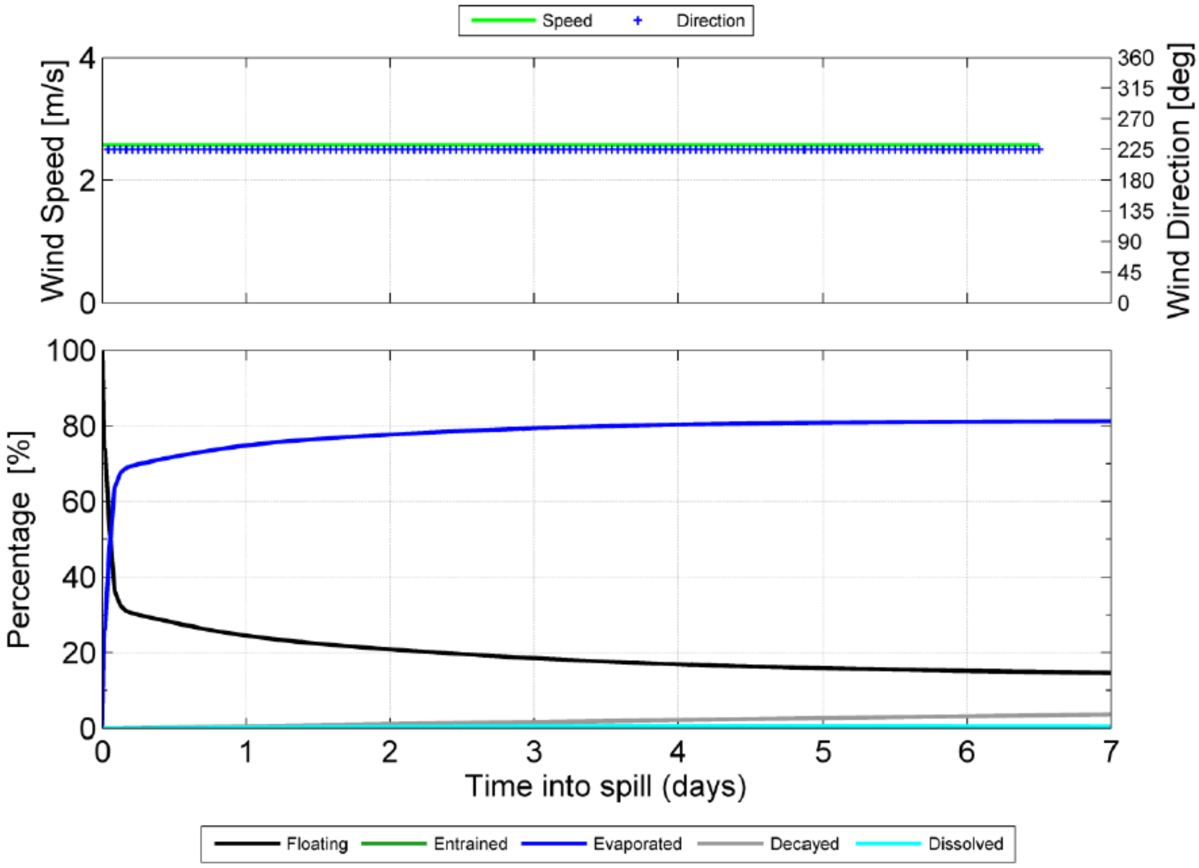

Figure 6-4: Proportional mass balance plot representing the weathering of Cossack light crude spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to a constant 5 kn (2.6 m/s) wind at 27 °C water temperature and 25 °C air temperature

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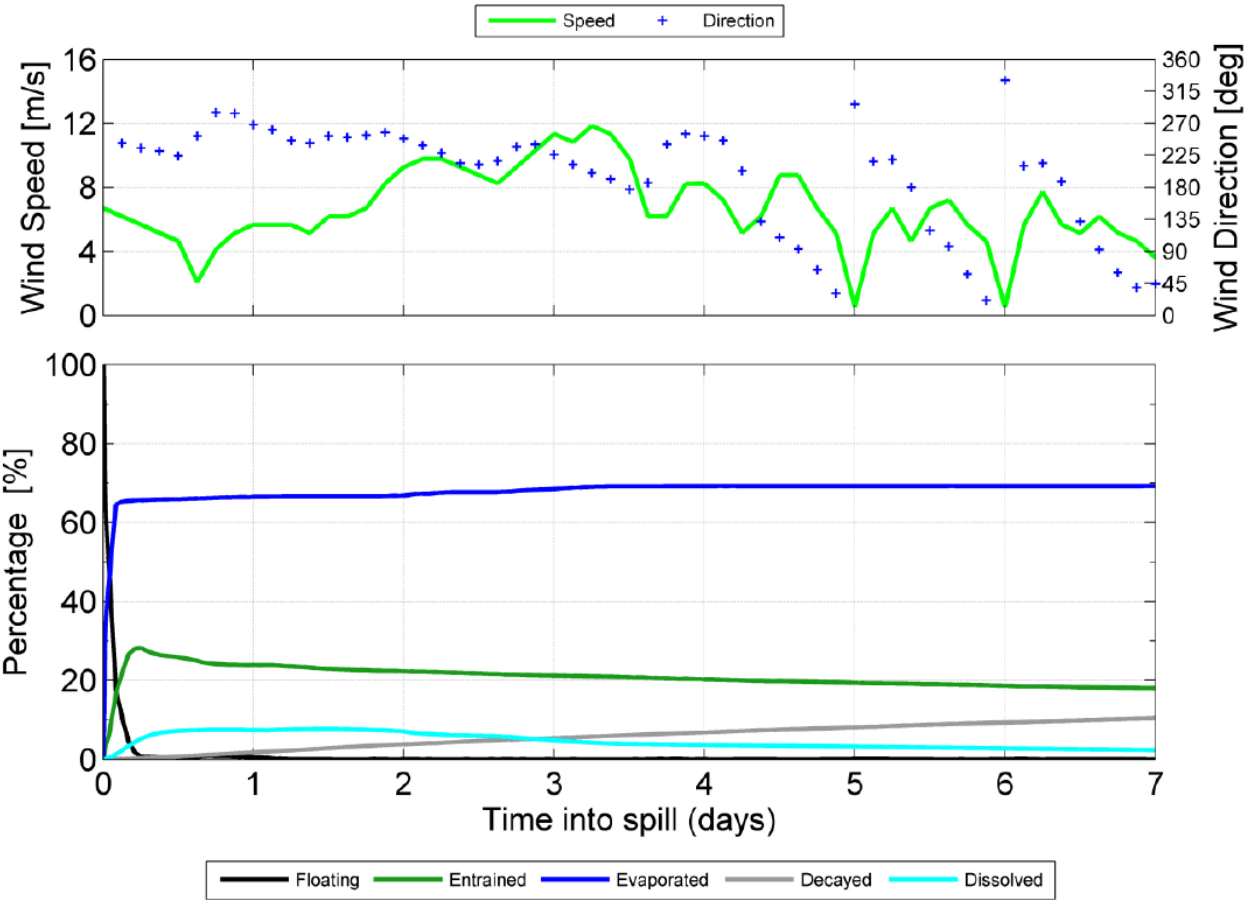

Figure 6-5: Proportional mass balance plot representing the weathering of Cossack light crude spilled onto the water surface as a one-off release (50 m³ over 1 hour) and subject to variable wind at 27 °C water temperature and 25 °C air temperature

Diesel

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

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

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

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Under the variable-wind case (Figure 6-5), where the winds are of greater strength, entrainment of diesel into the water column is indicated to be significant. Approximately two days after the spill, around 50% of the oil mass is forecast to have entrained and a further 45% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<2%). The residual compounds will tend to remain entrained beneath the surface under conditions that generate wind waves (approximately >6 m/s).

Biological and photochemical degradation is predicted to contribute to the decay of the floating slicks and oil droplets in the water column at an approximate rate of around 0.5% per day, for an accumulated total of about 3–4% after seven days in each wind case. However, given the large proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay and/or evaporate over time scales of several weeks to a few months. This long weathering duration will extend the area of potential effect, requiring the break-up and dispersion of the slicks and droplets to reduce concentrations below the thresholds considered in this study.

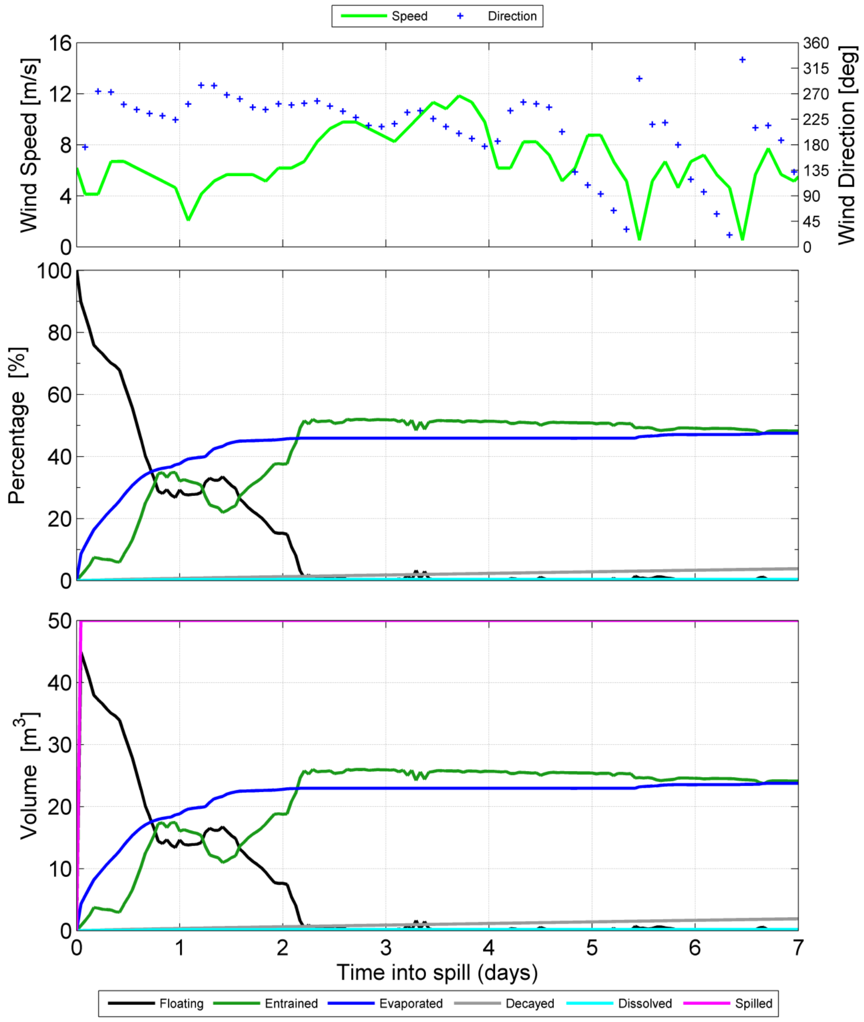

Figure 6-6: Mass balance plot representing, as proportion (middle panel) and volume (bottom panel), the weathering of diesel spilled onto the water surface as a one-off release (50 m^3 over 1 hour) and subject to variable winds (top panel) at 27 °C water temperature

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6.8.1.2 Environment that May Be Affected and Hydrocarbon Contact Thresholds

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental consequence, if a credible hydrocarbon spill scenario occurred, in terms of delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding hydrocarbon threshold concentrations. The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the ‘environment that may be affected’ (EMBA). The EMBA covers a larger area than the area that is likely to be affected during any single spill event, as the model was run for a variety of weather and metocean conditions, and the EMBA represents the total extent of all the locations where hydrocarbon thresholds could be exceeded from all modelling runs. Furthermore, as the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different EMBA is presented for each fate. These EMBA together have defined the spatial extent for the existing environment, which is described in Section 4.

The spill modelling outputs are presented as areas that meet threshold concentrations for surface, entrained and dissolved hydrocarbons for the modelled scenarios. Surface spill concentrations are expressed as grams per square metre (g/m^2), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb). A conservative approach—adopting accepted contact thresholds that are documented to impact the marine environment—is used to define the EMBA.

These hydrocarbon thresholds are presented in Table 6-17 and described in the following subsections.

Table 6-17: Summary of thresholds applied to the quantitative hydrocarbon spill risk modelling results

	Surface hydrocarbon (g/m^2)	Dissolved hydrocarbon (ppb)	Entrained hydrocarbon (ppb)	Accumulated hydrocarbon (g/m^2)
Cossack light crude	10	400	400	100
Diesel	10	500	500	10

Surface Hydrocarbon Threshold Concentrations

The spill modelling outputs defined the EMBA 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 2015) (Table 6-18). 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 (e.g. 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 ~10–25 g/m^2 (French et al. 1999, Koops et al. 2004, National Oceanic and Atmospheric Administration [NOAA] 1996, French-McCay 2018). Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers. The 10 g/m^2 threshold is the reported level of oiling to instigate impacts to seabirds, and is also applied to other wildlife, though it is recognised that ‘unfurred’ animals where hydrocarbon adherence is less may be less vulnerable. ‘Oiling’ at this threshold is taken to be of a magnitude that can cause a response from the most vulnerable wildlife such as seabirds. Due to weathering processes, surface hydrocarbons will have a lower toxicity due to changes in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact.

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Table 6-18: The Bonn Agreement oil appearance code

Appearance (following Bonn visibility descriptions)	Mass per area (g/m^2)	Thickness (µm)	Volume per area (L/km^2)
Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
Dull metallic colours	5 to 50	5 to 50	5000 to 50,000
Rainbow sheen	0.30 to 5.00	0.30 to 5.00	300 to 5000
Silver sheen	0.04 to 0.30	0.04 to 0.30	40 to 300

Dissolved Hydrocarbon Threshold Concentration

Cossack light crude

The threshold concentration value for dissolved hydrocarbons has been established with reference to results from Woodside-commissioned ecotoxicity tests on the crude oil that is produced at the Okha FPSO from the Cossack reservoir (Ecotox Services Australia [ESA] 2012).

The laboratory-based ecotoxicology tests used a range of Water Accommodated Fractions (WAF) concentrations to expose the different test organisms. For each ecotoxicity test, samples of the WAF were analysed to determine the total aromatics (C6-C28) present. Gas chromatography for aliphatic/aromatic speciation and total petroleum hydrocarbon analysis was used for semivolatile fractions (C10-C14, C15-C28, C29-C36) and volatile fractions (C6-C9). The purpose of the threshold is to inform the assessment of the potential for toxicity impacts to sensitive marine biota. Dissolved rather than total concentrations are generally considered to represent the bioavailable form of oil that dictates toxicity (Redman and Parkerton 2015). 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 focus on the early life stages of test organisms, when organisms are typically at their most sensitive. The ecotoxicology tests were conducted on seven mainly tropical–subtropical species representative from six major taxonomic groups (Table 6-19).

Table 6-19 presents the results of ‘no observed effect concentrations’ (NOECs) for Cossack light crude. The NOECs for the organisms tested ranged from 407 ppb to 6895 ppb. Based on these ecotoxicology tests, a conservative threshold of 400 ppb has been adopted. The oil spill modelling specifically represents the dissolved aromatic hydrocarbon content of Okha crude. Thresholds for instantaneous contact with aromatic hydrocarbons are based on the toxicity calculated specifically for the aromatic hydrocarbon for Okha crude. These thresholds are calculated based on exposure of organisms to dissolved aromatic hydrocarbons for periods of 1 to 96 hours and are, therefore, highly conservative.

Marine diesel

The dissolved aromatic threshold of 500 ppb for diesel has been selected as a conservative threshold to be consistent with the National Energy Resources Australia (NERA) Environment Plan Reference Case: Consequence analysis of an accidental release of diesel (NERA 2018). A threshold of 500 ppb is recommended in the reference case in accordance with a review by IRC (2011) of Group II Marine Gas Oil (MGO) hydrocarbon toxicity to the marine environment (NERA 2018).

Entrained Hydrocarbon Threshold Concentration

Cossack light crude

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

Entrained hydrocarbons present a number of possible mechanisms for harmful exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, hence have the

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

The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for the WAF of oil hydrocarbons. The thresholds for instantaneous contact with aromatic hydrocarbons are based on the toxicity calculated specifically for the aromatic hydrocarbon for Okha crude of 400 ppb (Table 6-19). The entrained oil droplets may contain soluble compounds and hence have the potential to generate elevated concentrations of dissolved hydrocarbons. Dissolved hydrocarbons rather than total concentrations are generally considered to represent the bioavailable form of oil that dictates toxicity; therefore, this approach is considered conservative.

The modelling of entrained hydrocarbons specifically represents the total volume of Okha crude predicted to be entrained under metocean conditions. As discussed above, the total aromatic threshold is conservative and is based on the exposure of organisms for periods of 1 to 96 hours and therefore is highly conservative when used for instantaneous contact.

Table 6-19: Summary of total aromatic NOECs for key life-histories of different biota based on toxicity tests for WAF of fresh Cossack (Okha) crude oil

Biota and Life Stage	Exposure duration (hrs)	NOEC – WAF concentration of unweathered crude oil showing no direct biological effect (ppb)
Sea urchin fertilisation	1	407
Sea urchin larval development	72	2496
Milky oyster larval development	48	1197
Micro-algal growth test	72	1554
Amphipod acute toxicity test	96	413
Copepod acute toxicity test	48	860
Larval fish imbalance test	96	6895
Kelp gemination test	72	682

Source: Ecotox Services Australia (2013)

Marine diesel

The entrained threshold for diesel has been selected to be consistent with the NERA Environment Plan Reference Case: Consequence analysis of an accidental release of diesel (2018:1003; NERA 2018). As described above, entrained droplets may contain soluble compounds and hence have the potential for generating elevated concentrations of dissolved hydrocarbons. However, the potential for physical and chemical effects from direct contact with entrained oil droplets, which are less biologically available, is more applicable. Therefore, an entrained threshold of 500 ppb, consistent with the threshold for toxicity from dissolved components, is considered to be conservative.

Accumulated Hydrocarbons Threshold Concentration

French-McCay (2009, 2016, 2018) defines accumulated hydrocarbons ≥100 g/m^2 to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat; therefore, ≥100 g/m^2 has been adopted as the threshold for shoreline accumulation.

6.8.2 MEEs Overview

Section 2.7 outlines the process for additional analysis and evaluation of MEEs. Sections 6.8.3 to 6.8.10 present the bowtie output for each MEE identified (Table 6-20).

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Table 6-20: MEE events for the Okha facility

No.	Hazard	Top Event
MEE-01	Liquid hydrocarbons in reservoirs, wells, wellheads and Xmas trees	Loss of well containment
MEE-02	Liquid hydrocarbons in subsea equipment (flowlines, manifolds, risers and associated equipment)	Subsea equipment loss of containment
MEE-03	Liquid hydrocarbons in topsides equipment	Topsides loss of containment
MEE-04	Liquid hydrocarbons in the Okha offtake system	Loss of containment during offtake
MEE-05	Hydrocarbons in Okha FPSO cargo tanks	Cargo tank loss of containment
MEE-06	Liquid hydrocarbons in the Okha FPSO and associated infrastructure	Loss of structural integrity
MEE-07	Liquid hydrocarbons in subsea equipment and Okha FPSO (topsides equipment, offtake system, cargo tanks)	Loss of marine vessel separation
MEE-08	Lifting activities associated with Okha FPSO operations	Loss of control of suspended load

Each section includes a summary of the hazard description, hazard management, emergency response, ALARP summary and a list of SCE barriers identified on the bowties. Each group of SCEs is listed under Technical Performance Standards, with consistent naming conventions used across Woodside's process safety management processes (e.g. pipeline integrity SCEs are captured as P09 – Pipeline Systems).

Section 6.8.11 presents the generic SCE Failure and generic Human Error bowties that illustrate the causes, outcomes and controls/barriers in place to manage potential common cause event (CCE) failure mechanisms for MEE controls associated with generic SCE equipment failure (CCE-01), and also human error (CCE-02). Controls and specific measures are listed for both bowties. Human Error is managed via the WMS and the Generic Human Error bowtie is included in the MEE section for completeness.

ALARP is demonstrated through controls and barriers being analysed for selection based on their independence, prioritised in accordance with the Hierarchy of Controls where controls further up the hierarchy take precedence over controls further down, and further analysed to consider the type of effect the control provides. ALARP controls presented for MEE bowties are labelled in accordance with Type of Effect classifications presented in Table 6-21.

Woodside has developed a tailored ALARP position for hydrocarbon spill response, including EPOs, EPSs and MC for preparedness and response. The response arrangements are a mitigative control that applies to all MEEs where a hydrocarbon release may credibly occur. The hydrocarbon spill response arrangements are described in Appendix D.

Table 6-21: Barrier hierarchy and type of effect

Type of Effect	Legend	Description
Elimination (Technical)		Elimination controls form the 'first line of defence'. They eliminate the underlying hazard and therefore are the most effective category of control measure. If practicable, they should be selected in preference to any other type, as their existence removes the need for any other controls (e.g. a corrosion-resistant metal could replace the original material of construction).
Elimination (Administration)		
Prevention (Technical)		Prevention controls are intended to remove certain causes of incidents or reduce their likelihood. The corresponding hazard remains, but the frequency of incidents involving the hazard is lowered (e.g. introduction of regular maintenance programs can prevent the development of events involving the hazard).
Prevention (Administration)		

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Type of Effect	Legend	Description
		Where hazards and causes could not be 'eliminated', controls are required to prevent them from leading to unwanted events and consequences.
Detection (Technical)		Detection controls are those that identify a potentially hazardous scenario (e.g. a change in operating parameters), allowing initiation of procedures or systems to prevent the cause occurring. Controls that detect the occurrence of events are often critical to being able to respond with other control measures that reduce the propagation of the events. Detection controls themselves often provide no actual control other than the awareness of the need to respond.
Detection Administration)		
Reduction/Control (Technical)		Reduction controls are intended to limit the scale and consequence of incidents. They include systems that detect incidents and take some action (e.g. to reduce the rate of leakage of a toxic gas) and also aspects such as inter-unit separation that prevent escalation of fire and explosion incidents. As there is always potential for controls to fail, additional measures are required to limit the scale and severity of any unwanted event or outcome that may arise, by providing the ability to intervene and limit the propagation of the events.
Reduction/Control (Administration)		
Mitigation (Technical)		Mitigation controls take effect in response to an incident. They include controls that lessen the significance or damage caused by an unwanted event. Such controls only take effect after the hazardous event and outcomes occur. Mitigation controls are generally those designed to protect personnel against the consequences of a hazard or to aid in recovering from the effects of the hazard.
Mitigation (Administration)		

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

Context		
Well and Reservoirs– Section 3.5.2	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risks Evaluation Summary

Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Release of hydrocarbons resulting from loss of subsea well containment.	-	X	X	X	X	X	X	B	A	0	M	LCS GP PJ RBA CV SV	Acceptable if ALARP	EPO 12

Description of Source of Risk

Background

A loss of well containment can lead to an uncontrolled release of reservoir hydrocarbons or other well fluids to the environment resulting in a well blowout. Woodside has identified a well blowout as the scenario with the worst-case credible environmental outcome as a result of this event. Due to the potential consequences, a loss of well containment is considered to be a MEE (MEE-01). A loss of well containment could occur because of:

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

A number of common failure causes due to human error and SCE Failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

Loss of Well Containment – Credible Scenarios

The Petroleum Activities Program includes production from a series of subsea wells (Section 3.5.2). A loss of well containment is not considered credible for the four temporarily abandoned exploration wells (Lambert 5ST1, Cossack-1, Goodwyn-6 and Angel-1). One credible worst-case loss of well containment scenario was identified for the Petroleum Activities Program:

- Well blowout at seabed – highest flow rate subsea well (LH3).

The credible worst-case subsea release was based on the maximum credible release volume from the highest flow rate subsea well (LH3). The loss of well containment scenario was modelled to a duration of 77 days. The estimated time required to successfully drill a relief well was 58 to 77 days. This takes into account time to prepare, mobilise and set up a drilling rig and also intersect and kill the well. Refer to Table 6-22 for additional discussion of relief well timing. The characteristics of Cossack (Okha) light crude was used as the basis in the modelling (refer to Section 6.8.1 for additional information on modelling methods and environmental impact, thresholds and hydrocarbon characteristics justifications).

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Table 6-22: Summary of worst-case loss of well containment hydrocarbon release scenario

Scenario	Hydrocarbon	Average Rate (m^3/day	Duration (days)	Depth (m)	Latitude (WGS84)	Longitude (WGS84)	Total Crude Release Volume (m^3)
Well blowout at seabed – subsea well with highest flow rate (LH3)	Cossack (Okha) light crude	2,414	77	80	19° 26' 58.47" S	116° 29' 16.23" E	185,915

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in well design and construction. In the company's recent history, it has not experienced any well integrity events that have resulted in significant releases or significant environmental impacts. The Okha facility has never experienced a worst-case loss of well containment in its operational history.

Decision Type

Decision Type B was applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications if the event is realised. To align with this decision type, a further level of analysis was applied using risk-based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling. CVs and SVs were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

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

Quantitative Spill Risk Assessment

Spill modelling of the worst-case credible loss of well containment spill scenario was undertaken by RPS APASA, on behalf of Woodside, over a 77-day simulation length to determine the fate of hydrocarbons released based on the assumptions in Section 6.8.1. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the EMBA and the potential impacts from the identified worst-case credible release volumes for all loss of well containment scenarios.

Consequence

The spatial extent and fate (including Weathering) of potential spilled hydrocarbon were considered during the impact assessment for a worst-case loss of well containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 4) and relevant literature and studies considering the effects of hydrocarbon exposure.

Likelihood

In accordance with the Woodside Risk Matrix, a worst-case loss of well containment has been defined as 0 (Remote). Information to support this likelihood determination is outlined below.

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

Separate analysis of blowout data collected between 1991 and 2010 in the North Sea and the Gulf of Mexico shows that only ten blowouts occurred during the production phase at a frequency of 1.36×10^{-5} blowouts per well year, with all these events occurring in the Gulf of Mexico and none in the North Sea (Scandpower 2013). North Sea standards of well design and operation are considered to be aligned with those applied by Woodside, as outlined in the Okha Well Operations Management Plan (WOMP). This data quantitatively supports the likelihood ranking as described above.

When considering likelihood from an 'experience' perspective, and considering likelihood of the environmental consequence of the blowout event, historic blowouts from production wells that have had a catastrophic impact to the environment ('A' consequence rating) have not occurred in the industry. This also further supports the likelihood ranking of 'Remote' for subsea wells.

Consequence Assessment

Environment that May be Affected

The overall EMBA for the Petroleum Activities Program is based on stochastic modelling, which compiles data from multiple hypothetical worst-case spill simulations under a variety of weather and metocean conditions (as described in

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Consequence Assessment
Section 6.8.1.2). The EMBA covers a larger area than the area that would be affected during any single spill event, and therefore represents the total extent of all locations where hydrocarbon thresholds could be exceeded from all modelling runs. The trajectory of a single spill would have a considerably smaller footprint. As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different EMBA is discussed for each fate. Surface Hydrocarbons Quantitative hydrocarbon spill modelling results for surface hydrocarbons are shown in Table 6-23. The modelled surface hydrocarbons are forecast to drift in all directions, reflecting the competing influence of both surface currents and winds across the wide area, and may extend up to 57 km from the release site at concentrations above the impact threshold (10 g/m²). Modelling results indicate no contact with sensitive receptors by surface (floating) hydrocarbons above the impact threshold at probabilities of 1% or greater due to the rapid weathering (evaporation/entrainment) of the hydrocarbon, as shown in Table 6-23. Entrained Hydrocarbons Quantitative hydrocarbon spill modelling results for entrained hydrocarbons are shown in Table 6-23. The modelled entrained hydrocarbons are forecast to potentially drift in all directions, with the most likely directions of travel being to the north-east and south-west of the release site. Contact by entrained oil at concentrations equal to or greater than 400 ppb is predicted at the Montebello AMP (31% probability), Montebello State Marine Park (18% probability), Barrow Island (12% probability), Pilbara Islands – Southern Island Group (19% probability) and Muiron Islands State Marine Park (17% probability), as well as several other receptors with probabilities lower than 10% (Table 6-23). The maximum entrained oil concentration forecast for any receptor is predicted at 1.8 ppm at the Montebello AMP. Table 6-23 indicates entrained threshold concentration contact locations for receptors as identified by the modelling. Dissolved Hydrocarbons Quantitative hydrocarbon spill modelling results for dissolved hydrocarbons are shown in Table 6-23. The modelled dissolved hydrocarbons are forecast to potentially drift in all directions, with the most likely directions of travel being to the north-east and south-west of the release site, extending up to 565 km from the release site. Contact by dissolved aromatic hydrocarbons at concentrations equal to or greater than 400 ppb is predicted to be greatest at Montebello Marine Park (23% probability), Glomar Shoal (17% probability), and Rankin Bank (16% probability), with possible contact at several other receptors at probabilities lower than 10% (Table 6-23). The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 3.6 ppm at the Montebello Marine Park. Accumulated Hydrocarbons Quantitative hydrocarbon spill modelling results for accumulated hydrocarbons are shown in Table 6-23. The Pilbara Islands – Southern Island Group (31% probability), the Montebello Islands (22% probability), Barrow Island (13% probability), and Muiron Islands (15% probability), as well as several other receptors with probabilities lower than 10% (Table 6-23), are predicted to experience shoreline accumulation in excess of the 100 g/m^2 threshold. Potential for accumulation of oil on shorelines is predicted to be greatest at the Pilbara Islands – Southern Island Group. ***Consequence Assessment Summary*** Table 6-23 presents the full extent of the EMBA; i.e. the sensitive receptors and their locations that may be exposed to hydrocarbons (surface, entrained, dissolved and accumulated) at or above the set threshold concentrations in the Remote likelihood of a major hydrocarbon release from a loss of well integrity occurring during the Petroleum Activities Program. Details of these receptors are outlined in Section 4. The potential biological and ecological impacts of an unplanned hydrocarbon release as a result of a loss of well integrity during the Petroleum Activities Program are presented in the following sections.

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Table 6-23: Key receptor locations and sensitivities potentially contacted above impact thresholds by the loss of well containment scenario with summary hydrocarbon spill contact (table cell values correspond to probability of contact [%])

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure [WM0000PG10055394])																													Probability of hydrocarbon contact and fate (%) (Cossack [Okha] light crude)			
		Physical		Biological																							Socioeconomic and Cultural							
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities / Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non-biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (foraging and internesting areas and significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Seabirds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas / Heritage – European and Indigenous / Underwater Cultural Heritage	Offshore Oil and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥400 ppb)	Dissolved aromatic hydrocarbon (≥400 ppb)	Accumulated hydrocarbons (>100 g/m²)
Offshore[24]	Montebello AMP	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		-	31	23	N/A
	Ningaloo AMP	✓	✓					✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓		-	1	1	N/A
	Gascoyne AMP	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	-	4	2	N/A
	Argo-Rowley Terrace AMP	✓	✓					✓							✓	✓			✓			✓	✓	✓		✓			✓		-	1	1	N/A
Submerged Shoals and Banks	Rankin Bank	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	16	N/A
	Glomar Shoal	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	17	N/A
	Rowley Shoals – Clerke Reef state MP	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	-	2
	Rowley Shoals – Imperieuse Reef State MP	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	-	8
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		-	18	8	22
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	-	12	2	13
	Lowendal Islands (including State Nature Reserve)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	-	-	-	13

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

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Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure [WM0000PG10055394])																													Probability of hydrocarbon contact and fate (%) (Cossack [Okha] light crude)			
		Physical		Biological																						Socioeconomic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities / Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non-biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (foraging and internesting areas and significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Seabirds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas / Heritage – European and Indigenous / Underwater Cultural Heritage	Offshore Oil and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥400 ppb)	Dissolved aromatic hydrocarbon (≥400 ppb)	Accumulated hydrocarbons (>100 g/m²)
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	19	4	31
	Pilbara Islands – Middle Island Group	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	-	-	4
	Pilbara Islands – Northern Island Group (Sandy Island Passage Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	-	-	7
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		-	17	10	15
	Dampier Archipelago	✓	✓	✓	✓	✓	✓				✓	✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	-	-	9
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	1	1	8
	Exmouth Gulf	✓	✓		✓	✓	✓	✓				✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓			-	-	-	-
	Shark Bay WHA	✓	✓	✓	✓	✓	✓					✓		✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		-	-	-	2
	Shark Bay – open Ocean Coast	✓	✓	✓	✓		✓	✓			✓	✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	-	-	2

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Summary of Potential Impacts to Environmental Values(s)	
Summary of Potential Impacts to protected species	
Setting	***Receptor Group***
Offshore	***Cetaceans*** A range of cetaceans were identified as potentially occurring within the Operational Area and wider EMBA (Section 4.5.2.5). In the event of a loss of well containment, surface, entrained, and dissolved hydrocarbons exceeding environmental impact threshold concentrations may drift across habitat for cetacean species. Migratory routes and BIAs of cetaceans considered to be MNES may be affected, including humpback whales and pygmy blue whales (northbound and southbound migrations). Cetaceans that have direct physical contact with surface, entrained, or dissolved aromatic hydrocarbons may suffer surface fouling, ingestion of hydrocarbons (from prey, water and sediments), aspiration of oily water or droplets, and inhalation of toxic vapours (Deepwater Horizon Natural Resource Damage Assessment Trustees [DHNRDT] 2016). This may result in the irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts, and organs. Other potential impacts include impairment of the immune system, neurological damage (Helm et al. 2015), reproductive failure, other adverse health effects (e.g. lung disease, poor body condition), and mortality (DHNRDT 2016). Physical contact with hydrocarbons is likely to have biological consequences for these species. Given cetaceans maintain thick skin and blubber, external exposure to hydrocarbons may result in irritation to skin and eyes. Hydrocarbons may also be ingested, particularly by baleen whales (e.g. pygmy blue whales and humpback whales), which feed by filtering large volumes of water. Geraci (1988) has identified behavioural disturbance through avoidance of spilled hydrocarbons in several species of cetacean, suggesting that cetaceans have the ability to detect surface slicks. However, observations during spills have recorded larger whales (both mysticetes and odontocetes) and smaller delphinids travelling through and feeding in oil slicks. During the Deepwater Horizon spill, cetaceans were routinely seen swimming in surface slicks offshore and nearshore (Aichinger Dias et al. 2017). In a review of the impacts of large scale hydrocarbon spills on cetaceans, it was found that exposure to oil from the Deepwater Horizon resulted in increased mortality to cetaceans in the Gulf of Mexico (DHNRDT 2016), and long-term population level impacts to killer whales were linked to the Exxon Valdez tanker spill (Matkin et al. 2008). Cetacean populations that are resident within the EMBA may be susceptible to impacts from spilled hydrocarbons if they interact with an area affected by a spill. Such species are more likely to occupy coastal waters (refer to the Mainland and Islands section below for additional information). Suitable habitat for oceanic toothed whales (e.g. sperm whales) and dolphins is broadly distributed throughout the region and as such, impacts are unlikely to affect an entire population. Other species identified in Section 4.5.2.5 may also have possible transient interactions with the EMBA (refer to Table 6-23 for the list of receptor locations for cetaceans). Pygmy blue whales and humpback whales are known to migrate seasonally through the wider EMBA; however, the migration BIAs in the region for both species do not overlap the Operational Area. A major spill in May to November would coincide with humpback whale migration through the waters off the Pilbara, North West Cape and Shark Bay (Figure 4-9). A major spill in April–August or October–January would coincide with pygmy blue whale migration (Figure 4-8). Both pygmy blue and humpback whales are baleen whales, so are most likely to be significantly impacted by toxic effects when feeding. However, feeding during migrations is low level and opportunistic, with most feeding for both species occurring in the Southern Ocean. Fresh hydrocarbons (i.e. typically in the vicinity of the release location) may have a higher potential to cause toxic effects when ingested, while weathered hydrocarbons are considered to be less likely to result in toxic effects. As such, the risk of ingestion of hydrocarbons is low. Pygmy blue whale and humpback whale migrations are protracted through time and space (i.e. the whole population will not be within the EMBA), and as such, a spill from the loss of well integrity is unlikely to affect an entire population. The humpback whale calving BIA in Camden Sound is not predicted to be contacted by hydrocarbons above threshold concentrations. Entrained hydrocarbons above threshold levels are not predicted to extend into Exmouth Gulf, which is a resting BIA for humpback whales during their southern migration. However, they are predicted at low probabilities to travel along the outer edge of the Exmouth Gulf as they move around the North West Cape, resulting in a small section of the EMBA overlapping the outer boundary of the humpback whale resting BIA. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore cetacean species, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to inshore cetaceans and other marine mammals are discussed in the Mainland and Islands (nearshore) impacts discussion below.

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Summary of Potential Impacts to Environmental Values(s)	
	Marine Turtles Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon spills (NOAA 2010). Therefore, contact with surface slicks or entrained hydrocarbon can result in hydrocarbons adhering to body surfaces (Gagnon and Rawson 2010) causing irritation of mucous membranes in the nose, throat and eyes, leading to inflammation and infection (NOAA 2010). Oiling can also irritate and injure skin, which is most evident on pliable areas such as the neck and flippers (Lutcavage et al. 1995). A stress response associated with this exposure includes an increase in the production of white blood cells, and even a short exposure to hydrocarbons may affect the functioning of the salt gland (Lutcavage et al. 1995). Hydrocarbons in surface waters may also impact turtles when they surface to breathe as they may inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours, which are the most toxic component of the hydrocarbon spill (Milton and Lutz 2003). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia, and neurological impairment (NOAA 2010). Contact with entrained hydrocarbons can result in hydrocarbons adhering to body surfaces, causing irritation of mucous membranes in the nose, throat and eyes and leading to inflammation and infection (Gagnon and Rawson 2010). An internesting BIA for flatback turtles overlaps the Goodwyn-6 suspended exploration well section of the Operational Area; however, the boundary of the BIA is 18 km from the Okha FPSO. Although this BIA overlaps the Operational Area, the Operational Area is unlikely to represent important habitat for marine turtles as there is an absence of potential nesting or foraging habitat for turtles (i.e. no emergent islands, reef habitat or shallow shoals) and the water is deep (~75 m to 130 m). However, it is acknowledged that there are significant nesting and foraging sites along the mainland coast and islands of the region, including Dampier Archipelago and the Montebello Island, and that a number of BIAs overlap the EMBA (Section 4.5.2.6 and Table 4-6). In particular the internesting BIAs and habitat critical to the survival of a species for loggerhead and hawksbill turtles extend for ~20 km from known nesting locations, and for ~60 km for flatback turtles. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore foraging marine turtles, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to nesting and internesting marine turtles are discussed in the Mainland and Islands (nearshore) impacts discussion below.
	Sea snakes Impacts to sea snakes from direct contact with hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles. They may include potential damage to the dermis and irritation to mucus membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation [ITOPF] 2011a). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, resulting in damage to their respiratory system. In general, sea snakes frequent the waters of the continental shelf area around offshore islands and potentially submerged shoals (water depths <100 m; see Submerged Shoals below). It is acknowledged that sea snakes may be present in the Operational Area and are present in the wider EMBA. Their abundance is not expected to be high in the deepwater and offshore environment. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore sea snakes, with consequence severity dependent on the duration and extent of a spill in relation to the distribution of sea snakes. Potential impacts to inshore and offshore reef associated sea snakes are discussed in the Submerged Shoals and Banks and Mainland and Islands (nearshore) impacts discussion below.
	Sharks, Sawfish and Rays Hydrocarbon contact may affect whale sharks through ingestion of entrained or dissolved hydrocarbons, particularly if feeding. Whale sharks may transit offshore open waters when migrating to and from Ningaloo Reef, where they aggregate for feeding from March to July (see Mainland and Islands (nearshore waters) below). Whale sharks may carry out opportunistic feeding in offshore waters and the Operational Area. The EMBA overlaps the whale shark foraging BIA identified in Section 4.5.2.7 and Figure 4-10, within which whale sharks are seasonally present between April and October. Impacts to sharks and rays may occur through direct contact with hydrocarbons, or through contamination of the tissues and internal organs, either through direct contact or through consumption of prey. As gill breathing

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Summary of Potential Impacts to Environmental Values(s)	
	organisms, sharks and rays may be vulnerable to toxic effects of dissolved hydrocarbons entering the body via the gills, and entrained hydrocarbons via coating of the gills inhibiting gas exchange. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore shark, sawfish and ray species, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to inshore and offshore reef associated sharks, sawfish and rays are discussed in the Submerged Shoals and Banks and Mainland and Islands (nearshore) impacts discussion below.
	Seabirds and/or Migratory Shorebirds Offshore waters are potential foraging grounds for seabirds associated with the coastal roosting and nesting habitat (e.g. Ningaloo, Muiron Islands and the Barrow/Montebello/Lowendal Island Group). There are confirmed foraging grounds off Ningaloo and the Barrow/Montebello/Lowendal Island Group. Foraging and breeding BIAs for a number of seabirds and migratory shorebirds overlap with the EMBA (Section Table 6-23 and Table 4-4): • the wedge-tailed shearwater (peak use August–April) • the roseate tern • the lesser crested tern • the fairy tern • the little tern • the lesser frigatebird • white-tailed tropic bird • brown booby • little tern. Seabirds and migratory birds are particularly vulnerable to contact with floating hydrocarbons, which may mat feathers. This may lead to hypothermia from loss of insulation, and to ingestion of hydrocarbons when preening to remove hydrocarbons; both impacts may result in mortality (Hassan and Javed 2011). Seabirds generally do not exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by several exposure pathways—primarily immersion, ingestion, and inhalation. Such contact with hydrocarbons may result in (AMSA 2013, International Petroleum Industry Environmental Conservation Association [IPIECA] 2004): • plumage fouling and hypothermia (loss of thermoregulation) • decreased buoyancy and consequent increased potential to drown • inability to fly or feed • anaemia • pneumonia • and irritation of eyes, skin, nasal cavities and mouths. Longer-term exposures may potentially impact seabird populations through loss of reproductive success, malformation of eggs or chicks (AMSA 2013), or mortality of individuals from oiling of feathers or the ingestion of hydrocarbons. A hydrocarbon spill may result in surface slicks disrupting a significant portion of the foraging habitat for seabirds, including foraging BIAs, which are generally associated with breeding habitats. Seabird distributions are typically concentrated around islands, so hydrocarbons near nesting/roosting areas may result in increased numbers of seabirds being impacted, with many species of seabirds, such as the wedge-tailed shearwater and the various species of tern, foraging relatively close to breeding islands/colonies. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore seabirds and migratory shorebirds, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to coastal and offshore island associated birds are discussed in the Mainland and Islands (nearshore) impacts discussion below.

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Summary of Potential Impacts to Environmental Values(s)	
Submerged Shoals and Banks	***Marine Turtles*** There is the potential for marine turtles to be present at submerged shoals such as Rankin Bank, Glomar Shoal and Rowley Shoals. These shoals and banks may, at times, be foraging habitat for marine turtles, given the coral and filter feeding biota associated with these areas. Satellite tracking of individual green turtles in the nearshore environment of the NWS did not indicate any overlap of the tracked post-nesting migratory routes and the Operational Area. However, it is acknowledged that individual marine turtles may be present at Glomar Shoal, Rankin Bank, Rowley Shoals and the surrounding areas. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to foraging marine turtles, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to nesting and internesting marine turtles are discussed in the Mainland and Islands (nearshore) impacts discussion below.
	Sea snakes There is the potential for sea snakes to be present at submerged shoals such as Glomar Shoal, Rankin Bank and Rowley Shoals. The potential impacts of exposure are as discussed previously in Offshore – Sea snakes. Sea snake species in Australia generally show strong habitat preferences (Heatwole and Cogger 1993); species that have preferred habitats associated with submerged shoals and oceanic atolls may be disproportionately affected by a hydrocarbon spill affecting such habitat. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore reef associated sea snakes, with consequence severity dependent on the duration and extent of a spill in relation to the distribution of sea snakes. Potential impacts to inshore sea snakes are discussed in the Mainland and Islands (nearshore) impacts discussion below.
	Sharks, Sawfish and Rays There is the potential for resident shark and ray populations to be impacted directly from hydrocarbon contact, or indirectly through contaminated prey or loss of habitat. Spill model results indicate Glomar Shoal and Rankin Bank are predicted to be contacted by dissolved hydrocarbons above threshold concentrations). Shark and ray species that have associations with submerged shoals and oceanic atolls may be more susceptible to a reduction in habitat quality resulting from a hydrocarbon spill. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to offshore reef associated shark, sawfish and ray species, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions. Potential impacts to inshore associated sharks, sawfish and rays are discussed in the Mainland and Islands (nearshore) impacts discussion below.
Mainland and Islands (Nearshore Waters)	***All Species*** The information provided on protected species in this section is in addition to that provided in the preceding Offshore and Oceanic Reefs and Submerged Banks and Shoals sections. Refer to these preceding sections for additional discussion of protected species.
	Cetaceans and Dugongs In addition to a number of whale species that may occur in nearshore waters (refer to Section 4.5.2.5) or the full list of EPBC listed cetacean species identified by the PMST with potential to occur within the EMBA), coastal populations of small cetaceans and dugongs are known to reside or frequent nearshore waters, including the Ningaloo Coast, Muiron Islands, Montebello/Barrow/ Lowendal Islands Group, Pilbara Southern Island Group (see Table 6-23) which may be potentially impacted by entrained and dissolved hydrocarbons exceeding threshold concentrations in the event of a loss of well containment. The predicted EMBA extends past Exmouth Gulf towards Shark Bay. The Exmouth Gulf is a known humpback whale aggregation area on the annual southern migration (September to December); therefore, humpbacks moving into the Gulf may be exposed to hydrocarbons above thresholds levels. However, entrained and dissolved hydrocarbons concentrations above thresholds are not expected within Exmouth Gulf itself. No hydrocarbon contact at or above threshold concentrations is expected for Camden Sound, an important calving area for humpback whales. The potential impacts of exposure are as discussed previously in Offshore – Cetaceans. However, nearshore populations of cetaceans and dugongs are known to exhibit site fidelity and are often resident populations. Therefore, avoidance behaviour may have greater impacts to population functioning. Nearshore dolphin species (e.g. spotted bottlenose dolphins) may exhibit higher site fidelity than oceanic species, although Geraci (1988) observed relatively little impacts beyond behavioural disturbance. Additional potential environment impacts may also include the potential for

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Summary of Potential Impacts to Environmental Values(s)	
	dugongs to ingest hydrocarbons when feeding on oiled seagrass stands, or indirect impacts to dugongs due to loss of this food source due to dieback in worst-affected areas. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to inshore cetacean species and dugongs, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions.
	Marine Turtles Several marine turtle species use nearshore waters and shorelines for foraging and breeding (including internesting), with significant nesting beaches along the mainland coast and islands in potentially impacted locations such as the Dampier Archipelago, Montebello/Barrow/Lowendal Islands Group, Pilbara Islands (Northern, Middle, and Southern Island Groups), and Ningaloo Reef. There are distinct breeding seasons, as detailed in Section 4.5.1.3. The nearshore waters of these turtle habitat areas may be exposed to surface, entrained or dissolved hydrocarbons exceeding threshold concentrations, and accumulated hydrocarbons above threshold concentrations. A number of BIAs have been identified for marine turtles, including nesting, internesting and foraging areas. A hydrocarbon spill above impact thresholds in these areas may result in impacts to biologically important behaviours. During the breeding season, turtle aggregations near nesting beaches within the wider EMBA are most vulnerable due to greater turtle densities, and potential impacts may occur at the population level of some marine turtle species. The potential impacts of exposure are as discussed previously in Offshore – Marine Turtles. In the nearshore environment, turtles can ingest hydrocarbons when feeding (e.g. on oiled seagrass stands/macroalgae) or can be indirectly affected by loss of food source (e.g. seagrass due to dieback from hydrocarbon exposure) (Gagnon and Rawson 2010). In addition, hydrocarbon exposure can impact turtles during the breeding season at nesting beaches. Contact with gravid adult females or hatchlings may occur on nesting beaches (accumulated hydrocarbons) or in nearshore waters (entrained hydrocarbons) where hydrocarbons are predicted to make shoreline contact. Results from studies of nesting beaches subject to extensive oil pollution from the Deepwater Horizon spill indicated a significant reduction (~44%) in turtle nest density during the nesting season immediately following the spill (Lauritsen et al. 2017). Lauritsen et al. (2017) partially attributed this reduction to direct (e.g. direct mortality of adults due to oiling or toxicity) and indirect (e.g. shoreline disturbance from response activities) impacts from the spill. There was a significant increase in nesting density in the years immediately following the spill, with nesting density returning to levels comparable to pre-spill densities within two nesting seasons (Lauritsen et al. 2017). This indicates that adult female turtles that avoided mortality may have deferred nesting during the spill until subsequent years. The significant decline in nesting density observed following the Deepwater Horizon spill represents a decline of ~36% of reproductive output of the turtle population in the study area (Lauritsen et al. 2017); given turtles may take over a decade to reach sexual maturity, the effects of such a reduction in reproductive output may take over a decade to appear in nesting-related metrics (which are commonly used to monitor turtle populations). Based on the modelling results and the potential for impact and recovery of turtles, a worst-case hydrocarbon spill from a loss of well containment may result in reduced turtle numbers and nesting density; however, it would not be expected to result in elimination of a population. To date, no oil spills have been demonstrated to have resulted in elimination of a turtle population at any scale (Yender and Mearns 2010). Disastrous spills impacting important turtle habitat (including nesting areas) have not been shown to eliminate turtle populations, although direct and indirect impacts have been documented (e.g. Lauritsen et al. 2017, McDonald et al. 2017, Stacy et al. 2017, Vander Zanden et al. 2016). Turtle populations have been shown to be able to recover, even when populations have been reduced to small sizes after experiencing significant declines (Mazaris et al. 2017). As such, population-scale impacts to marine turtles from a worst-case loss of well containment would be expected to exhibit recovery, although may take several decades to reach pre-impact population levels due to the relatively long lifespan and late sexual maturity of marine turtle species. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to nesting marine turtles, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' mating and nesting seasons and overall distributions.
	Sea snakes 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 2011a).

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Summary of Potential Impacts to Environmental Values(s)	
	Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to sea snakes, with consequence severity dependent on the duration and extent of a spill in relation to the distribution of sea snakes.
	Sharks, Sawfish and Rays Whale sharks and manta rays are known to frequent the Ningaloo Reef system and the Muiron Islands (forming feeding aggregations in late summer/autumn). Whale sharks and manta rays generally transit along the nearshore coastline and are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies, including passive subsurface ram-feeding and active surface feeding (Taylor 2007). Passive feeding involves 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). Individuals that are present in worst-affected spill areas would have the potential to ingest toxic amounts of entrained or dissolved aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect endocrine and immune systems in the longer term. The presence of hydrocarbons may displace whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by surface, entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are fish eggs and phytoplankton, which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If the spill event occurred during the spawning season, this important food supply (in worst spill-affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by the whale shark may also result in long-term impacts as a result of bioaccumulation. There is the potential for other resident shark and ray (e.g. sawfish species identified in Section 4.5.2.7) populations to be impacted directly from hydrocarbon contact or indirectly through contaminated prey or loss of habitat. Table 6-23 indicates the receptor locations predicted to be impacted from entrained and/or dissolved aromatic hydrocarbons to the benthic communities of nearshore, subtidal communities, and it is considered that there is the potential for habitat loss to occur. Therefore, the consequences to resident shark and ray populations (if present) from loss of habitat, may result in a disruption to a significant portion of the population; however, it is not expected to impact the overall viability of the population. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to inshore associated shark, sawfish and ray species, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions.
	Seabirds and/or Migratory Shorebirds In the event of a major spill, there is the potential for seabirds, and resident, non-breeding overwintering shorebirds that use the nearshore waters for foraging and resting, to be exposed to entrained, dissolved, and accumulated hydrocarbons. This could result in lethal or sublethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in waters near their breeding colony. This results in relatively higher seabird densities in these areas during the breeding season, making these areas particularly sensitive in the event of a spill. Pathways of biological exposure that can result in impact may occur through ingesting contaminated fish (nearshore waters) or invertebrates (intertidal foraging grounds such as beaches, mudflats and reefs). Ingestion can also lead to internal injury to sensitive membranes and organs (IPIECA 2004). Whether the toxicity of ingested hydrocarbons is lethal or sublethal will depend on the weathering stage and its inherent toxicity. Exposure to hydrocarbons may have longer-term effects, with impacts to population numbers due to decline in reproductive performance and malformed eggs and chicks affecting survivorship, and loss of adult birds. Important areas for foraging seabirds and migratory shorebirds are identified in Section 4.5.2.8. Refer to Table 6-24 for locations within the predicted extent of the EMBA that are identified as habitat for seabirds and migratory shorebirds. Suitable habitat for seabirds and shorebirds are broadly distributed along the mainland and nearshore island coasts within the EMBA. Important nesting and resting areas include:

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Summary of Potential Impacts to Environmental Values(s)	
	• Muiron Islands • Ningaloo Coast • Montebello/Barrow/Lowendal Islands Group (including known nesting habitats on Boodie, Double and Middle Islands) • Pilbara Islands North, Middle, and South Island Group (refer to Section 4.5.2.3 for additional information, including BIAs within the wider EMBA). Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to inshore associated seabirds and migratory shorebirds, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements, breeding seasons and distributions.

Summary of potential impacts to other species	
Setting	***Receptor Group***
All Settings	***Pelagic Fish Populations*** Fish mortalities are rarely observed to occur as a result of hydrocarbon spills (ITOPF 2011b). This has generally been attributed to the possibility that pelagic fish are able to detect and avoid surface waters underneath hydrocarbon spills by swimming into deeper water or away from the affected areas. Fish that have been exposed to dissolved aromatic hydrocarbons are capable of eliminating the toxicants once placed in clean water, so individuals exposed to a spill are likely to recover (King et al. 1996). Where fish mortalities have been recorded, the spills (resulting from the groundings of the tankers *Amoco Cadiz* in 1978 and the *Florida* in 1969) have occurred in sheltered bays. Laboratory studies have shown that adult fish are able to detect hydrocarbons in water at very low concentrations, and large numbers of dead fish have rarely been reported after hydrocarbon spills (Hjermann et al. 2007). This suggests that juvenile and adult fish are capable of avoiding water contaminated with high concentrations of hydrocarbons. However, sublethal impacts to adult and juvenile fish may be possible, given long-term exposure (days to weeks) to polycyclic aromatic hydrocarbon (PAH) concentrations (Hjermann et al. 2007), which are typically the most toxic components of hydrocarbons. Light molecular weight aromatic hydrocarbons (i.e. one- and two-ring molecules) are generally soluble in water, which increases bioavailability to gill-breathing organisms such as fish. The effects of exposure to oil on the metabolism of fish appears to vary according to the organs involved, exposure concentrations and route of exposure (waterborne or food intake). Oil reduces the aerobic capacity of fish exposed to aromatics in the water and, to a lesser extent, affects fish consuming contaminated food (Cohen et al. 2005). The liver, a major detoxification organ, appears to be the organ where anaerobic activity is most impacted, probably increasing anaerobic activity to help eliminate ingested oil from the fish (Cohen et al. 2005). Fish are perhaps most susceptible to the effects of spilled oil in their early life stages, particularly during egg and planktonic larval stages, which can become entrained in spilled oil. Contact with oil droplets can damage feeding and breathing apparatus of embryos and larvae (Fodrie and Heck 2011). The toxic hydrocarbons in water can result in genetic damage, physical deformities and altered developmental timing for larvae and eggs exposed to even low concentrations over prolonged timeframes (days to weeks) (Fodrie and Heck 2011). More subtle, chronic effects on the life history of fish as a result of exposure in early life stages to hydrocarbons include disruption to complex behaviours such as predator avoidance, reproductive and social behaviour (Hjermann et al. 2007). Prolonged exposure of eggs and larvae to weathered concentrations of hydrocarbons in water has also been shown to cause immunosuppression and allows expression of viral diseases (Hjermann et al. 2007). PAHs have also been linked to increased mortality and stunted growth rates of early life history (pre-settlement) of reef fishes, as well as behavioural impacts that may increase predation of post-settlement larvae (Johansen et al. 2017). However, the effect of a hydrocarbon spill on a population of fish in an area with fish larvae and/or eggs, and the extent to which any of the adverse impacts may occur, depends greatly on prevailing oceanographic and ecological conditions at the time of the spill and its contact with fish eggs or larvae. Demersal species are associated with the Ancient Coastline KEF, which overlaps the Operational Area. Additional KEFs that may host relatively diverse or abundant fish assemblages compared to relatively featureless continental shelf habitats occur within the wider EMBA: • Continental Slope Demersal Fish Communities KEF (68 km west), which has a highly diverse fish assemblage with a high degree of endemism (DoEE 2019)

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Summary of potential impacts to other species	
	• Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF (260 km south-west), which has been shown to host demersal fish (BMT Oceanica 2016) • Glomar Shoal KEF (37 km east), which is important area for a number of commercial and recreational fish species such as rankin cod, brown striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish (Falkner et al. 2009) • Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals KEF (308 km north-east), which has high species richness, high biological productivity, and hosts aggregations of marine life (DoEE 2019) • Exmouth Plateau KEF (181 km west), which is an important area of biodiversity (DoEE 2019) • Commonwealth Waters adjacent to Ningaloo Reef KEF (204 km south-west), which has high biological productivity and hosts a yearly aggregation of whale sharks (DoEE 2019). Mortality and sublethal effects may impact populations located close to a well blowout and within the EMBA for entrained/dissolved aromatic hydrocarbons (≥400 ppb). Additionally, if prey (infauna and epifauna) surrounding the well location and within the EMBA is contaminated, this can result in the absorption of toxic components of the hydrocarbons (PAHs), potentially impacting fish populations that feed on these. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to pelagic fish species, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to species' migratory movements and distributions.

Summary of Potential Impacts to Marine Primary Producers	
Setting	***Receptor Group***
Submerged Shoals	The waters overlying the Rankin Bank and Glomar Shoal have the potential to be exposed to dissolved hydrocarbons above threshold concentrations (≥400 ppb). Potential biological impacts could include sublethal stress and, in some instances, total or partial mortality of sensitive benthic organisms such as corals and the early life stages of resident fish and invertebrate species. Other submerged shoals and banks within the wider EMBA (e.g. Rowley Shoals) are not predicted to be exposed to entrained or dissolved hydrocarbons above threshold concentrations, but may be exposed to accumulated shoreline hydrocarbons above impact thresholds (Table 6-23). Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to primary producer groups at Rankin Bank and Glomar Shoal, with lower consequence severity predicted for Rowley Shoals given its increased distance from the potential release location.
Mainland and Islands (nearshore waters)	***Coral Reef*** The quantitative spill risk assessment indicates there would be potential for coral reef habitat to be exposed to dissolved and entrained hydrocarbons at locations including the Montebello Islands, Barrow Island, Lowendal Islands, discrete locations within the Pilbara Islands Southern Island Group, Muiron Islands and low potential to contact the Ningaloo Coast (Table 6-23). The shallow coral habitats are most vulnerable to hydrocarbon coating by direct contact with surface slicks during periods when corals are exposed at spring low tides. Water-soluble hydrocarbon fractions associated with surface slicks are also known to cause high coral mortality via direct physical contact of hydrocarbon droplets to sensitive coral species, such as the branching coral species (Shigenaka 2001). While surface slicks are not expected to form in nearshore waters, accumulated hydrocarbons along the shoreline are predicted to occur, which could impact on intertidal coral habitats. 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). Exposure to entrained hydrocarbons/dissolved aromatic hydrocarbons (≥400 ppb) has the potential to result in lethal or sublethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals), reef flat (intertidal corals) and lagoonal (back reef) coral communities. Mortality in a number of coral species is possible, and this would result in the reduction of coral cover and change in the composition of coral communities. Sublethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates, and impaired reproduction (Negri and Heyward 2000). This could result in impacts to the shallow water fringing coral communities/reefs of the offshore islands (e.g. Barrow/Montebello/Lowendal Islands, Pilbara Southern and Northern Island

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Summary of Potential Impacts to Marine Primary Producers	
	Groups) and the mainland coast (e.g. Ningaloo Coast). With reference to Ningaloo Reef, wave-induced water circulation flushes the lagoon and may promote removal of entrained and dissolved hydrocarbons from this particular reef habitat. Under typical conditions, breaking waves on the reef crest induce a rise in water level in the lagoon, creating a pressure gradient that drives water in a strong outward flow through channels. These channels are across as much as 15% of the length of Ningaloo Reef (Taylor and Pearce 1999). If a spill occurs at the time of coral spawning at potentially affected coral locations, or in the general peak period of biological productivity, there is the potential for a significant reduction in successful fertilisation and coral larval survival, due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained and dissolved aromatic hydrocarbons, resulting in sublethal impacts and in some cases mortality—particularly early life-stages of coral reef animals (reef-attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site-attached, have small home ranges, and as reef residents they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities (which may include fringing reefs of the offshore islands and/or the Ningaloo Reef system) will depend on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities. Over the worst-affected sections of reef habitat, coral community live cover, structure and composition is predicted to reduce, manifested by loss of corals and associated sessile biota. Recovery of these impacted reef areas typically relies on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. For example, there is evidence that Ningaloo Reef corals and fish are partly self-seeding, with the supply of larvae from locations within Ningaloo Reef of critical importance to the healthy maintenance of the coral communities (Underwood 2009). Recovery at other coral reef areas may not be aided by a large supply of larvae from other reefs, with levels of recruits after a disturbance event only returning to previous levels after the numbers of reproductive corals had also recovered (Gilmour et al. 2013). Therefore, a worst-case hydrocarbon spill scenario has the potential to result in catastrophic long-term impacts to coral populations within the EMBA, with consequence severity predicted to be greatest at reefs closest to the potential release location (e.g. Montebello Islands).
	Seagrass Beds/Macroalgae and Mangroves Spill modelling has predicted that entrained, dissolved, and accumulated hydrocarbons above threshold concentrations have the potential to contact a number of discrete shoreline sensitive receptors, such as those supporting biologically diverse, shallow subtidal and intertidal communities. The variety of habitat and community types, from the upper subtidal to the intertidal zones support a high diversity of marine life and are used as important foraging and nursery grounds by a range of invertebrate and vertebrate species. Depending on the trajectory of the entrained/dissolved plume, macroalgal/seagrass communities including the Barrow/Montebello/Lowendal Islands, the Pilbara Islands (documented as low and patchy cover), and the Ningaloo Coast (patchy and low cover associated with the shallow limestone lagoonal platforms), all have the potential to be exposed (see Table 6-23 for a full list of receptors within the EMBA). Seagrass in the subtidal and intertidal zones have different degrees of exposure to hydrocarbon spills. Subtidal seagrass is generally considered much less vulnerable to surface oil spills than intertidal seagrass, primarily because freshly spilled hydrocarbons, including crude oil, float under most circumstances. Dean et al. (1998) found that oil mainly affects flowering; therefore, species that are able to spread through apical meristem growth are not as affected (such as *Zostera*, *Halodule* and *Halophila* species). Seagrass in the intertidal zone is particularly vulnerable, as it may come into direct contact with surface hydrocarbons, as well as entrained components, which can smother and kill seagrasses if it coats their leaves and stems (Taylor and Rasheed 2011). This conclusion is supported by Howard et al. (1989) who noted that surface hydrocarbon spills that become stranded on the seagrass and smother it during the rise and fall of the tide can result in reduced growth rates, blackened leaves and mortality. Wilson and Ralph (2011) concluded that long-term impacts to seagrass are unlikely unless hydrocarbona are retained within the seagrass meadow for a sustained duration. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al. 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should lower the content of soluble aromatic components before contact occurs. Exposure to entrained/dissolved aromatic hydrocarbons may result in mortality, depending on actual entrained/dissolved aromatic hydrocarbon concentration received and duration of exposure.

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Summary of Potential Impacts to Marine Primary Producers	
	Physical contact with entrained hydrocarbon droplets could cause sublethal stress, causing reduced growth rates and reduced tolerance to other stress factors (Zieman et al. 1984). Mangrove habitat and associated mudflats and salt marsh at Ningaloo Coast (small habitat areas), the Pilbara islands, and the Montebello Islands were identified within the EMBA (see Table 6-23 for the full list of receptors). Hydrocarbons coating prop roots of mangroves can occur from surface hydrocarbons when hydrocarbons are deposited on the aerial roots. Hydrocarbons deposited on the aerial roots can block the pores used to breathe, or interfere with the trees' salt balance, resulting in sublethal and potential lethal effects. Mangroves can also be impacted by entrained/dissolved aromatic hydrocarbons that may adhere to the sediment particles. In low-energy environments such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (NOAA 2014). The hydrocarbons comprise a proportion of persistent residual fractions. Therefore, deposited hydrocarbons are likely to persist in the sediment, potentially causing chronic sublethal toxicity impacts beyond immediate physical and acute effects, which may delay recovery in an affected area. Recovery of mangroves from oil spills can take 20–30 years (NOAA 2014); therefore, recovery from any impacts would be long-term (>10 years). Entrained/dissolved hydrocarbon impacts may include sublethal stress and mortality to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss of habitats and/or lethal and sublethal in-water toxic effects. This may result in mortality or impairment of growth, survival and reproduction. In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays and crustaceans that use these intertidal habitat areas for breeding, feeding and nursery habitat purposes. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to seagrass beds, macroalgae communities and mangroves within the EMBA, with consequence severity predicted to be greatest at receptors closest to the potential release location (e.g. Montebello Islands).

Summary of Potential Impacts to Other Habitats and Communities	
Setting	***Receptor Group***
Offshore	***Benthic Fauna Communities*** In the event of a major release at the seabed, the stochastic spill model predicted hydrocarbons droplets would be entrained, rapidly transporting them to the sea surface. As a result, the low sensitivity benthic communities associated with the unconsolidated, soft sediment habitat and any epifauna (filter feeders) associated with the Canyons KEF and the Continental Slope Demersal Fish Communities KEF (Section 4.7.5) within the wider EMBA are not expected to have widespread exposure to released hydrocarbons. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to seabed and associated epifauna and infauna within the EMBA, with impacts predicted to be greatest for habitats closest to the potential release location.
	Open Water – Productivity/Upwelling Primary production by plankton (triggered by sporadic upwelling events in the offshore waters) is an important component of the primary marine food web. Planktonic communities are generally mixed, including phytoplankton (cyanobacteria and other microalgae), secondary consuming zooplankton (e.g. copepods), and the eggs and larvae of fish and invertebrates (meroplankton). Exposure to hydrocarbons in the water column can result in changes in species composition, with declines or increases in one or more species or taxonomic groups (Batten et al. 1998). Phytoplankton may also experience decreased rates of photosynthesis (Tomajka 1985). For zooplankton, direct effects of contamination may include suffocation, changes in behaviour, or environmental changes that make them more susceptible to predation. Impacts on plankton communities are likely to occur in areas where surface, entrained or dissolved aromatic hydrocarbon threshold concentrations are exceeded, but communities are expected to recover relatively quickly (within weeks or months). This is due to high population turnover, with copious production within short generation times that also buffers the potential for long-term (i.e. years) population declines (ITOPF 2011a). Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to plankton populations within the EMBA, with impacts predicted to be greatest for habitats closest to the potential release location.
	Filter Feeders

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<table>
<tr><th colspan="2">Summary of Potential Impacts to Other Habitats and Communities</th></tr>
<tr><td></td><td>Hydrocarbon exposure may occur to offshore filter feeding communities (e.g. communities on hard substrate associated with the Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF and Continental Slope Demersal Fish Communities KEF or other locations as identified in Section 4.7.5), depending on the depth of the entrained/dissolved hydrocarbons. Exposure to entrained/dissolved aromatic hydrocarbons (≥400 ppb) has the potential to result in lethal or sublethal toxic effects. Sublethal impacts, including mucus production and polyp retraction, have been recorded for gorgonians exposed to hydrocarbon (White et al. 2012). Any impacts may result in localised long-term effects to community structure and habitat.

Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to filter feeders within the EMBA, with impacts predicted to be greatest for habitats closest to the potential release location.</td></tr>
<tr><td rowspan="4">Mainland and Islands (Nearshore Waters)</td><td>Open Water – Productivity/Upwelling
Nearshore waters and adjacent offshore waters surrounding the offshore islands (e.g. Montebello/ Barrow/Lowendal Islands Group) and to the west of the Ningaloo Reef system are known locations of seasonal upwelling events and productivity. The seasonal productivity events are critical to krill production, which supports megafauna aggregations such as whale sharks and manta rays in the region. This has the potential to result in lethal and sublethal impacts to a certain portion of plankton in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. However, recovery would occur (see Offshore description above).

Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to plankton populations within the EMBA.</td></tr>
<tr><td>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 reaches nursery areas close to the shore (e.g. seagrass and mangroves) (ITOPF 2011a). Fish spawning (including for commercially targeted species such as snapper and mackerel) occurs in nearshore waters at certain times of the year, and nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters.

Modelling indicated that, in the event of a major spill, there is potential for entrained or dissolved hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters, including Montebello/Barrow/Lowendal Islands Group, Pilbara Southern and Northern Islands Groups, Ningaloo Coast, and the Muiron Islands. This has the potential to result in lethal and sublethal impacts to a portion of fish larvae in areas contaminated above impact thresholds, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Although there is the potential for spawning/nursery habitat to be impacted (e.g. mangroves and seagrass beds, discussed above), losses of fish larvae in worst-affected areas are unlikely to be of major consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). This is supported by a recent study in the Gulf of Mexico, which used juvenile abundance data from shallow-water seagrass meadows as indices of the acute, population-level responses of young fishes to the Deepwater Horizon spill. Results indicated that there was no change to the juvenile cohorts following the Deepwater Horizon spill. Additionally, there were no significant post-spill shifts in community composition and structure, nor were there changes in biodiversity measures (Fodrie and Heck 2011).

Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to spawning fish and/or nursery areas within the EMBA, with consequence severity dependent on the actual timing, duration and extent of a spill in relation to key spawning periods and locations.</td></tr>
<tr><td>Non-biogenic Reefs
The reef communities fringing the Pilbara region (e.g. Pilbara islands) may be exposed to dissolved or entrained hydrocarbons (at or above threshold concentrations), and consequently exhibit lethal or sublethal impacts resulting in partial or total mortality of keystone sessile benthos, particularly hard corals; thus, potential community structural changes to these shallow, nearshore benthic communities may occur. If these reefs are exposed to entrained or dissolved hydrocarbons, impacts are expected to result in localised long-term effects.

Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to non-biogenic reefs within the EMBA.</td></tr>
<tr><td>Filter Feeders</td></tr>
</table>

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<table>
<tr><th colspan="2">Summary of Potential Impacts to Other Habitats and Communities</th></tr>
<tr><td></td><td>Hydrocarbon exposure to filter feeding communities (e.g. Montebello Islands) may occur, depending on the depth of the entrained and dissolved aromatic hydrocarbons. See discussion above on potential impacts.

Nearshore filter feeders that are present in shallower water <20 m may potentially be impacted by entrained hydrocarbon through lethal/sublethal effects (see discussion for Offshore Filter Feeders). Nearshore filter feeder communities identified in the Dampier Archipelago may be exposed to hydrocarbons. Such impacts may result in localised, long term effects to community structure and habitat.

Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to filter feeders within the EMBA.</td></tr>
<tr><td></td><td>Sandy Shores/Estuaries/Tributaries/Creeks (including Mudflats)/Rocky Shores

Shoreline exposure for the upper and lower areas differ. The upper shore has the potential to be exposed to surface slicks, while the lower shore is subjected to dissolved or entrained oil.

Potential impacts may occur due to surface hydrocarbon contact with intertidal areas, including sandy shores, mudflats and rocky shores, as listed in Table 6-23. Hydrocarbons at sandy shores are incorporated into fine sediments through mixing in the surface layers from wave energy, penetration down worm burrows and root pores (IPIECA 2000). Hydrocarbons in the intertidal zone can adhere to sand particles; however, high tide may remove some or most of the hydrocarbons back out of the sediments. Typically, hydrocarbons are only incorporated into the surface layers to a maximum of 10 cm (ITOPF 2000). It is predicted that a number of sandy shores along the coastline may have accumulated hydrocarbons ≥100 g/m^2 (see Table 6-23). As described earlier, accumulated hydrocarbons ≥100 g/m^2 could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat. The persistence of the hydrocarbons will depend on the wave exposure but can be months to years.

The impact of oil on rocky shores largely depends on the incline and energy environment. On steep/vertical rock faces on wave-exposed coasts, there is likely to be no impact from a spill event. However, a gradually sloping boulder shore in calm water can potentially trap large amounts of oil (IPIECA 2000). The impact of the spill on marine organisms along the rocky coast will depend on the toxicity and weathering of the hydrocarbon. Similar to sandy shores, accumulated hydrocarbons ≥100 g/m^2 could coat the epifauna along rocky coasts and impact the reproductive capacity and survival. The location of rocky shores where impacts are predicted are listed in Table 6-23.

Intertidal mudflats are susceptible to potential impacts from hydrocarbons, as they are typically low-energy environments and therefore trap oils. Intertidal mudflats have been identified in the EMBA along the Ningaloo coast (see Table 6-23). The extent of oiling is influenced by the neap and spring tidal cycle, and seasonal highs and lows that affect mean sea level. Potential impacts to tidal flats include heavy accumulations covering the flat at low tide; however, it is unlikely that oil will penetrate the water-saturated sediments. However, oil can penetrate fine sediments through animal burrows and root pores. It has been demonstrated that infaunal burrows allow hydrocarbons to enter subsurface sediments, where it can be retained for months.

The toxicity of stranded surface hydrocarbons and the in-water toxicity of the entrained or dissolved hydrocarbons reaching the shorelines will determine impacts to marine biota such as sessile barnacle species and/or mobile gastropods and crustaceans such as amphipods. Lethal and sublethal impacts may be expected where the entrained or dissolved hydrocarbon concentration threshold is >400 ppb. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to shorelines within the EMBA.</td></tr>
<tr><td>Key Ecological Features</td><td>Key Ecological Features

KEFs potentially impacted by the hydrocarbon spill from a loss of well containment event are detailed in Section 4.7.5. Although these KEFs are primarily defined by seabed geomorphological features, they can indicate a potential for increased biological productivity and, therefore, ecological significance.

The consequences of a hydrocarbon spill from a loss of well containment event are predicted to result in moderate impacts to values of the KEFs affected (for the values of each KEF, see Section 4.7.5). Potential impacts include contamination of sediments, impacts to benthic sediment fauna and associated impacts to demersal fish populations, and reduced biodiversity as described above and below. Most KEFs within the EMBA have relatively broad-scale distributions and are unlikely to be significantly impacted. KEFs within the EMBA that are not associated with broad-scale distributions (i.e. Glomar Shoal, and Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals). Glomar Shoal is predicted to be contacted by dissolved hydrocarbons, while Rowley Shoals is only predicted to be contacted at low probabilities, and by accumulated shoreline hydrocarbons.</td></tr>
</table>

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Summary of Potential Impacts to Other Habitats and Communities	
	Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major long-term impacts to at Rankin Bank and Glomar Shoal, with lower consequence severity predicted for Rowley Shoals given its increased distance from the potential release location. No significant impacts are predicted to other KEFs within the EMBA (i.e. consequence of no lasting effect).

Summary of Potential Impacts to Water Quality	
Setting	***Aspect***
All Settings	***Open Water – Water Quality*** Water quality would be affected due to hydrocarbon contamination above impact thresholds. These are defined by the EMBA descriptions for each of the entrained and dissolved hydrocarbon fates and their predicted extent. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to water quality within the EMBA, with impacts predicted to be greatest for areas closest to the potential release location.

Summary of potential impacts to marine sediment quality	
Setting	***Receptor Group***
Offshore	***Marine Sediment Quality*** Studies of hydrocarbon concentrations in deep-sea sediments in the vicinity of a catastrophic well blowout indicated hydrocarbon from the blowouts can be incorporated into sediments (Romero et al. 2015). Proposed mechanisms for hydrocarbon contamination of sediments include sedimentation of hydrocarbons and direct contact between submerged plumes and the seabed (Romero et al. 2015). In the event of a major hydrocarbon release at the seabed, modelling indicates that a pressurised release of hydrocarbon would form droplets that would be transported into the water column to the surface (i.e. transported away from the seabed). As a result, the extent of potential impacts to the seabed area at and surrounding the release site would be largely confined to a localised footprint. Marine sediment quality would be reduced as a consequence of hydrocarbon contamination for a small area within the immediate release site for a long to medium term, as hydrocarbons in sediments typically undergo slower weathering and degradation (Diercks et al. 2010, Liu et al. 2012). There is the potential for floating and entrained hydrocarbons to sink following extensive weathering and adsorption of sediment particles, which may result in the deposition of hydrocarbons to the seabed in areas distant from the release location. Such hydrocarbons are expected to be less toxic due to the weathering process. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in slight, short-term impacts to offshore sediment quality within the EMBA, with impacts predicted to be greatest for areas closest to the potential release location.
Mainland and Islands (Nearshore waters)	***Marine Sediment Quality*** Entrained and dissolved hydrocarbons (at or above the defined thresholds) are predicted to potentially contact shallow, nearshore waters of identified islands and mainland coastlines. Hydrocarbons may accumulate (at or above the ecological threshold) at a range of nearshore receptors (refer to Table 6-23). Such hydrocarbon contact may lead to reduced marine sediment quality by several processes, such as adherence to sediment and deposition shores or seabed habitat. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to sediment quality within the EMBA, with impacts predicted to be greatest for areas closest to the potential release location.

Summary of Potential Impacts to Air Quality
A hydrocarbon release during a loss of well containment has the potential to result in short-term reduction in air quality. There is potential for human health effects on workers in the immediate vicinity of atmospheric emissions. The ambient concentrations of VOCs released from diffuse sources is difficult to accurately quantify, although their behaviour and fate is predictable in open offshore environments, as VOC emissions disperse 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. Given the Remote likelihood of occurrence of a loss of well containment, the temporary nature of any VOC emissions (from either gas surfacing or weathering of liquid hydrocarbons from a loss of well containment), the predicted behaviour and fate of VOCs in open offshore environments, and the significant distance from the Operational Area to

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Summary of Potential Impacts to Air Quality
the nearest sensitive airshed (town of Dampier ~119 km away), a worst-case hydrocarbon spill scenario has the potential to result in minor, short-term impacts to air quality within the EMBA, with impacts predicted to be greatest for areas closest to the potential release location.

Summary of Potential Impacts to Protected Areas
The quantitative spill risk assessment results indicate that the open-water environment protected within a number of Commonwealth AMPs (refer to Table 6-23) may be affected by released hydrocarbons in the event of a loss of well containment. In the Remote likelihood of a major spill occurring, entrained and/or dissolved hydrocarbons may contact the identified key receptor locations of islands and mainland coastlines, resulting in the actual or perceived contamination of protected areas as identified for the EMBA. Impact on the protected areas is discussed in the sections above for ecological values and sensitivities, and below for socioeconomic values. Additionally, such hydrocarbon contact may alter stakeholder understanding and/or perception of the protected marine environment, given these represent areas are largely unaffected by anthropogenic influences and contain biologically diverse environments.

Summary of Potential Impacts to Socioeconomic Values	
Setting	***Receptor Group***
Offshore	***Fisheries – Commercial*** A hydrocarbon release during a loss of well containment event has the potential to result in direct impacts to target species of Commonwealth and State fisheries within the defined EMBA (refer Table 4-8). Lethal and sublethal effects may impact localised populations of targeted species within the EMBA for entrained/dissolved hydrocarbons (≥400 ppb). However, entrained hydrocarbons are likely to be confined in the upper water column; therefore, demersal species are less likely to be exposed to hydrocarbons than pelagic species. A major loss of hydrocarbons from the Petroleum Activities Program may also lead to an exclusion of fishing from the spill-affected area for an extended period. Fish exposure to hydrocarbon can result in 'tainting' of their tissues. Even very low levels of hydrocarbons can impart a taint or 'off' flavour or smell in seafood. Tainting is reversible through the process of depuration, which removes hydrocarbons from tissues by metabolic processes, although its efficacy delpends on the magnitude of the hydrocarbon contamination. Fish have a high capacity to metabolise these hydrocarbons, while crustaceans (such as prawns) have a reduced ability (Yender et al. 2002). Seafood safety is a major concern associated with spill incidents. Therefore, actual or potential seafood contamination can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (Yender et al. 2002). A major spill would result in the establishment of an exclusion zone around the spill-affected area. There would be a temporary prohibition on fishing activities for a period of time, and subsequent potential for minor economic impacts to affected commercial fishing operators. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major, long-term impacts to commercial fisheries within the EMBA, particularly for pelagic fisheries and fisheries with most of their effort focused within the EMBA (e.g. Pilbara Demersal Scalefish Managed Fishery and Mackerel Managed Fishery). Potential impacts to inshore fisheries are discussed in the Mainland and Islands (nearshore) impacts discussion below, and the impact assessment relating to spawning is discussed above.
	Tourism including Recreational Activities Recreational fishers predominantly target large tropical species, such as emperor, snapper, grouper, mackerel, trevally and other game fish. Recreational angling activities include shore-based fishing, private boat and charter boat fishing, with peak activity between April and October (Smallwood et al. 2011) for the Exmouth region. Limited recreational fishing takes place in the offshore waters of the Operational Area. Impacts on species that are recreationally fished are described above under Summary of Potential Impacts to Other Species. A major loss of hydrocarbons from the Petroleum Activities Program may lead to exclusion of marine nature-based tourist activities, resulting in a loss of revenue for operators. Tourism is a major industry for the region and visitor numbers would likely reduce if a hydrocarbon spill were to occur, based on the perception of hydrocarbon spills and associated impacts. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in moderate, medium-term impacts to tourism and recreation within the EMBA.

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Summary of Potential Impacts to Socioeconomic Values	
	Offshore Oil and Gas Infrastructure A hydrocarbon release during a loss of well containment event has the potential to result in disruptions to production at existing petroleum facilities (platforms and FPSOs), as well as activities such as drilling and seismic exploration. For example, facility water intakes for cooling and fire hydrants could be shut off if contacted by floating hydrocarbons, which could in turn lead to the temporary cessation of production activities. Spill exclusion zones established to manage the spill could also prohibit access for activity support vessels as well as offtake tankers approaching facilities off the North West Cape. The impact on ongoing operations of regional production facilities would be determined by the nature and scale of the spill and metocean conditions. Furthermore, decisions on the operation of production facilities in the event of a spill would be based primarily on health and safety considerations. The closest production facilities are: • NRC (operated by Woodside): overlapping the Operational Area (32 km from the Okha FPSO) – predicted to be contacted by floating hydrocarbons • Angel Facility (operated by Woodside): overlapping the Operational Area (20 km from the Okha FPSO) – predicted to be contacted by floating hydrocarbons • GWA (operated by Woodside): 11 km from the Operational Area • Reindeer (operated by Santos): 45 km from the Operational Area. Operation of these facilities is likely to be affected in the event of a well blowout spill. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in slight, short-term impacts to oil and gas industry within the EMBA.
Submerged Shoals	***Tourism and Recreation*** A hydrocarbon release during a loss of well containment event has the potential to result in a temporary prohibition on charter boat recreational fishing/diving and any other marine nature-based tourism trips to Rankin Bank, Glomar Shoal and Rowley Shoals. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in moderate, medium-term impacts to tourism and recreational activities within the EMBA.
Mainland and Islands (Nearshore Waters)	***Fisheries – Commercial*** Nearshore Fisheries and Aquaculture In the event of a loss of well containment, there is the possibility that target species in some areas used by a number of state fisheries could be affected, including wild oysters in the Pearl Oyster Managed Fishery that are within the EMBA and several west coast fisheries (refer to Table 4-8 for fisheries within the wider EMBA). Targeted fish, prawn, mollusc and lobster species and pearl oysters could experience sublethal stress, or in some instances mortality, depending on the concentration and duration of hydrocarbon exposure and its inherent toxicity. Prawn Managed Fisheries In the event of a major spill, the modelling indicated the entrained and dissolved EMBA may extend to nearshore waters, including the actively fished areas of the designated Onslow Prawn Managed Fishery, Exmouth Gulf Prawn Managed Fishery, Broome Prawn Managed Fishery, Nickol Bay Prawn Managed Fishery, and the Shark Bay Prawn and Scallop Managed Fishery, and managed prawn nursery areas. Note: Most of the demarcated area for the prawn managed fishery in the Exmouth Gulf is outside the EMBA. Prawn habitat usage differs between species in the post-larval, juvenile and adult stages (Dall et al. 1990) and direct impacts to benthic habitat due to a major spill have the potential to impact prawn stocks. For example, juvenile banana prawns are found almost exclusively in mangrove-lined creeks (Rönnbäck et al. 2002), whereas juvenile tiger prawns are most abundant in areas of seagrass (Masel and Smallwood 2000). Adult prawns also inhabit coastline areas but tend to move to deeper waters to spawn. In the event of a major spill, a range of subtidal habitats that support juvenile prawns may be exposed to hydrocarbons above impact thresholds, including: • Montebello Islands • Barrow Island • Lowendal Islands • Pilbara Northern, Middle, and Southern Island Groups • Shark Bay • Ningaloo Coast. Localised loss of juvenile prawns in the worst spill-affected areas is possible. Whether lethal or sublethal effects occur will depend on duration of exposure, hydrocarbon concentration and

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Summary of Potential Impacts to Socioeconomic Values	
	weathering stage of the hydrocarbon, and its inherent toxicity. Furthermore, seafood consumption safety concerns and a temporary prohibition on fishing activities may lead to subsequent potential for economic impacts to affected commercial fishing operators. Therefore, a worst-case hydrocarbon spill scenario has the potential to result in major, long-term impacts to commercial fisheries within the EMBA.
	Tourism and Recreation In the event of a major spill, the nearshore waters of offshore islands and reefs as well as the Ningaloo coast could be reached by entrained hydrocarbons and dissolved hydrocarbons, depending on prevailing wind and current conditions. As these locations offer a number of amenities such as fishing, swimming and using beaches and surrounds, they have a recreational value for local residents and visitors. If a well blowout event resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering, tides, currents or oil spill response (e.g. shoreline clean-up if safe to do so) removes the hydrocarbons. In the event of a well blowout, tourists and recreational users may also avoid areas due to perceived impacts, including after the oil spill has dispersed. Typically, a hydrocarbon spill that results in visible slicks in coastal waters and on shorelines will disrupt recreational activities, particularly tourism and its supporting services. In the event of a well blowout, hydrocarbons may accumulate on shorelines (at or above a set threshold) (see Table 6-23 for the full list of receptors). As a result of potential accumulation on beaches, it is expected that there will be a temporary cessation of all marine-based tourism activities on the spill-affected coast and wider coastal area for a period of weeks or longer, until natural weathering or tides and currents remove the hydrocarbons or clean-up operations remove beached oil. There is the potential for stakeholder perception that this environment will be contaminated over a large area and for the longer term, resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill-related tourism impacts and found that, on average, it took 12 to 28 months to return to baseline visitor spending. There is likely to be significant impacts to the tourism industry, wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up, and change in any public perceptions regarding the spill (Oxford Economics 2010). Therefore, a worst-case hydrocarbon spill scenario has the potential to result in moderate, medium-term impacts to tourism and recreational activities within the EMBA.
	Cultural Heritage A number of Underwater Cultural Heritage sites (including historic shipwrecks) have been identified in the vicinity of Operational Area. The spill modelling results do not predict surface slicks will contact any identified wrecks. However, shipwrecks occurring in the subtidal zone will be exposed to entrained/dissolved hydrocarbons, and marine life that shelter and take refuge in and around these wrecks may be affected by in-water toxicity of dispersed hydrocarbons. The consequences of such hydrocarbon exposure may include large fish species moving away, and/or resident fish species and sessile benthos such as hard corals exhibiting sublethal and lethal impacts (which may range from physiological issues to mortality). Entrained hydrocarbons above threshold concentrations (>400 ppb) and accumulated hydrocarbons above thresholds (>100 g/m^2) are predicted at the Montebello/Barrow/Lowendal islands. Artefacts, scatter and rock shelters are on land above the high water mark on Barrow and Montebello islands; therefore, no contact by surface or accumulated hydrocarbons is predicted for these areas. Within the wider EMBA are several designated heritage places (Section 4.6.1). These places are also covered by other designations such as World Heritage Area. Potential impacts are discussed in the sections above.

MEE-01 Loss of Well Containment – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-01; refer to Figure 6-7, Figure 6-8, and Figure 6-9 for bowtie diagrams.

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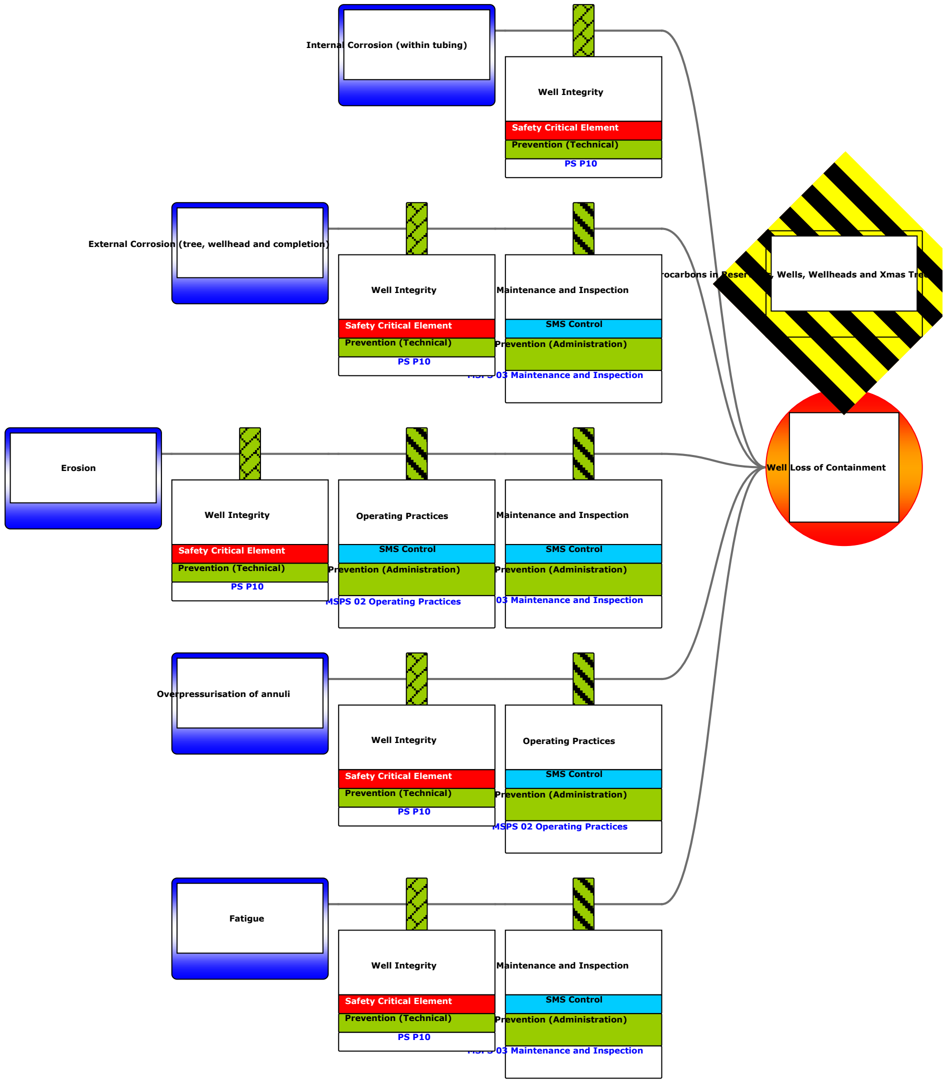

Figure 6-7: MEE-01 Wells Loss of Containment (Causes 1–5)

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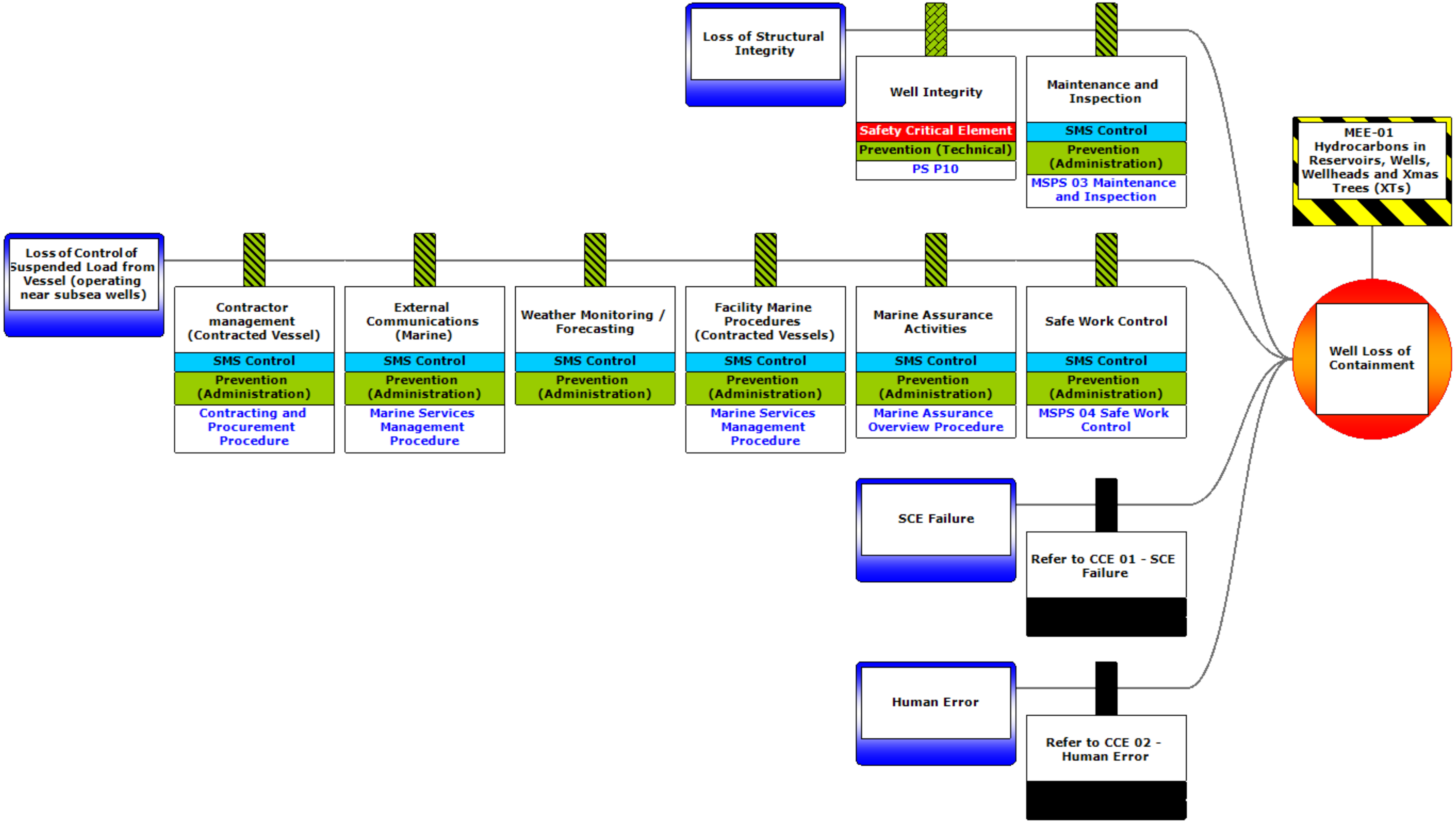

Figure 6-8: MEE-01 Wells Loss of Containment (Causes 6–9)

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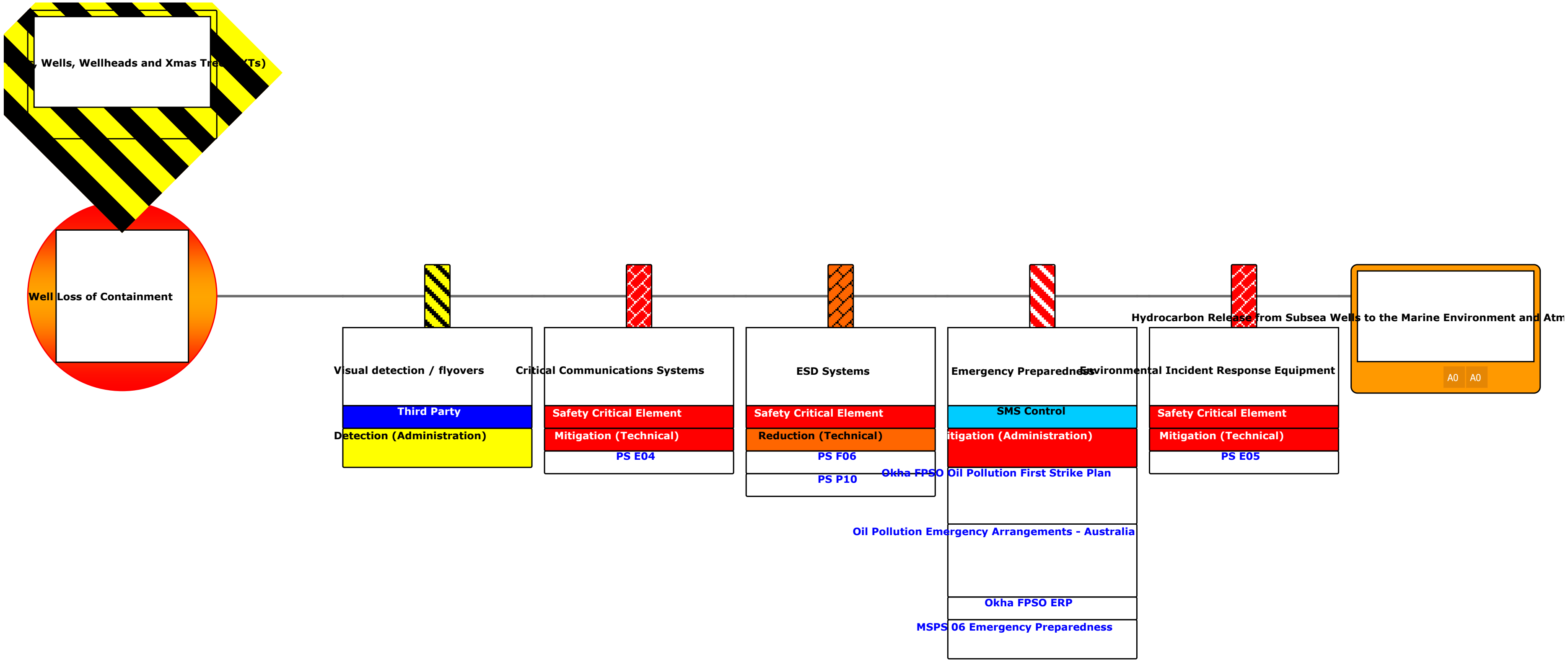

Figure 6-9: MEE-01 Wells Loss of Containment (Outcomes)

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MEE-01 Loss of Well Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	N/A	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain well mechanical integrity to contain reservoir fluids within the well envelope to avoid a MEE.	P10 – Wells	Prevention (Technical)	Yes **C 12.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate response to accidents and emergencies.	E04 – Safety Critical Communication	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain safety instrumented system (safety instrumented functions and emergency shutdown actions) to detect and respond to predefined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition so as to prevent or mitigate the effects of a MEE.	F06 – Safety Instrumented System P10 – Wells	Reduction / Control (Technical)	Yes **C 12.3**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011: Accepted Well Operations Management Plan (WOMP) to demonstrate that the risks to well integrity are managed in accordance with sound engineering principles, standards, specifications, and good oilfield practice. It describes the systems that are in place to ensure well design and integrity is managed for the well lifecycle, thus contributing to management of associated potential environmental	Okha FPSO Well Operations Management Plan	Prevention / Mitigation (Administration) Control based on legislative requirements – must be adopted)	Yes **C 12.5**

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MEE-01 Loss of Well Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	consequences of well integrity events.			
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.	Okha FPSO Operations Safety Case	Prevention / Mitigation (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • M02 Operating Practices • M03 Maintenance and Inspections • M04 Safe Work Control • Management of Change – Assets Procedure (Temporary Equipment) • Marine Services Management Procedure • Marine Assurance Overview Procedure • Contracting and Procurement Procedure	MSPS-02 Operating Practices MSPS-03 Maintenance and Inspection MSPS-04 Safe Work Control Management of Change – Assets Procedure (Temporary Equipment) Marine Services Management Procedure Marine Assurance Overview Procedure Contracting and Procurement Procedure ISSoW Manual	Prevention (Administration)	Yes – See Section 7

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MEE-01 Loss of Well Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	• Integrated Safe System of Work (ISSoW) Manual.			
Emergency Response and Contingency Planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	Emergency Preparedness Okha Emergency Response Plan (ERP) Okha Oil Pollution First Strike Plan (Appendix H) Oil Pollution Emergency Arrangements – Australia	Mitigation (Administration)	Yes Refer to Section 7 for a discussion around the ALARP assessment of controls related to hydrocarbon spill response.

Risk-based Analysis

For risks identified as MEEs, a more detailed risk-based bowtie analysis (as outlined in Section 2.7.3) was used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls were selected following hierarchy of control principles and consider independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside's Risk Management Procedures and implementation of the WOMP ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability
- wells integrity codes and standards.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical PSs which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-01; refer to Figure 6-7, Figure 6-8, and Figure 6-9 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer to Section 6.8.1 for details of the method used).

Company Values

Corporate values require all personnel at Woodside to comply with appropriate policies, standards, procedures and processes while being accountable for their actions and holding others to account in line with the Woodside Compass. As detailed above, the Petroleum Activities Program will be undertaken in line with these policies, standards and procedures, which include suitable controls to prevent loss of well containment, and response if a loss of well containment occurs.

Societal Values

Due to the Petroleum Activities Program's proximity to sensitive receptors (e.g. Montebello Islands, Glomar Shoal, Rankin Bank, Dampier Archipelago) and the potential extent of the wider EMBA, the loss of well containment risk rating presents a Decision Type B in accordance with the decision support framework described in Section 2.6.1. Extensive consultation was undertaken for this program to identify the views and concerns of relevant stakeholders, as described in Section 5.

Woodside sent an activity Information sheet to all identified relevant stakeholders regarding the Petroleum Activities Program (Section 5 and Appendix F). Woodside consulted with AMSA and WA Department of Transport (DoT) on spill response strategies. In accordance with the MOU between Woodside and AMSA, a copy of the Okha Oil Pollution First Strike Plan (Appendix H) was provided to AMSA.

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MEE-01 Loss of Well Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a very low likelihood unplanned hydrocarbon release as a result of a loss of well containment.

The principle of inherent safety and environmental protection is based on preventing the MEE (through design of well integrity) and ensuring the wells are operated within their design envelope (through operating practices) and assurance (through maintenance and inspection). If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory that can be released and by implementing remediation.

The controls in place for preventing and mitigating MEEs are specified and assured by implementing the Okha WOMP, SCE management procedures including technical performance standards for SCEs and Management System Performance Standards (MSPSs) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures, and implementation of the WOMP ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability
- wells integrity codes and standards.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, it is considered that MEE risk associated with loss of well containment from Okha FPSO subsea wells are managed to ALARP.

Demonstration of Acceptability

Acceptability Statement

Loss of well containment has been evaluated as having a 'Moderate' risk rating. As per Section 2.6.3.1, Woodside considers 'Moderate' risk ratings as acceptable if ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained.

Acceptability is demonstrated with regard to the considerations below.

Principles of ESD

Woodside has a strong history of exploration and development of oil and gas reserves in the North West of WA with an excellent environmental record, while providing revenue to State and Commonwealth Governments, returns to shareholders, jobs and support to local communities. Titles for oil and gas exploration are released based on commitments to explore with the aim of uncovering and developing resources. It is under the lease agreement that Woodside has determined the potential to develop the hydrocarbon fields for which acceptance of this EP is sought under the Environment Regulations.

Woodside has established a number of research projects in order to understand the marine environments in which they operate, notably in the Exmouth Region and the Kimberley Region, including Rankin Bank, Glomar Shoal, Enfield Canyon and Scott Reef. Where scientific data do not exist, Woodside assumes that a pristine natural environment exists and therefore, implements all practicable steps to prevent damage. Woodside's corporate values require that we consider the environment and communities in which we operate when making decisions.

Woodside looks after the communities and environments in which it operates. Risks are inherent in petroleum activities; however, through sound management, systematic application of policies, standards, procedures and processes, Woodside considers that despite this risk, the extremely low likelihood of loss of well containment is acceptable.

Internal Context

The Petroleum Activities Program is consistent with Woodside corporate policies, standards, procedures, processes and training requirements as outlined in the Demonstration of ALARP and EPOs, including:

- Woodside Health, Safety, Environment and Quality Policy (Appendix A)
- Woodside Risk Management Policy (Appendix A)
- The SCE technical performance standards developed and implemented for the Okha FPSO.

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Demonstration of Acceptability
Oil spill preparedness and response strategies are considered applicable to the nature and scale of the risk and associated impacts of the response are considered reduced to ALARP (Appendix D). Monitoring and evaluation (operational monitoring) as a key response in the unlikely event of a hydrocarbon release will assess and track the extent of the hydrocarbon contact and revise the predicted extent of impact. In addition, the planning area for scientific monitoring (refer to Section 5.7 of the Oil Spill Assessment and Mitigation Plan) can be re-assessed in the unlikely event of hydrocarbon release with consideration of the conservation values and social-cultural values of state and Commonwealth protected areas (including AMPs), National and Commonwealth Heritage Listed places; tourism and recreation; and fisheries. The post-response SMP will consider assessment and monitoring in line with the affected receptors such as habitat and species, AMPs, fisheries. ***External Context – Societal Values*** Woodside recognises that its licence to operate from a regulator and societal perspective is based on historical performance, complying with appropriate policies, standards and procedures, and understanding the expectations of external stakeholders. External stakeholder consultation, outlined below, was undertaken prior to the Petroleum Activities Program: • consultation with AMSA and WA DoT on spill response strategies. In accordance with the MOU between Woodside and AMSA, a copy of the Okha Oil Pollution First Strike Plan (Appendix H) was provided to AMSA and DoT. • consultation with other relevant stakeholders (Section 5); stakeholder feedback was incorporated into this EP where appropriate. By providing hydrocarbon spill response measures that are commensurate with the risk rating, location and sensitivity of the receiving environment (including social and aesthetic values), Woodside believes that this addresses societal concerns to an acceptable level. ***Other Requirements (includes laws, policies, standards and conventions)*** The Petroleum Activities Program is consistent with laws, policies, standards and conventions, including: • accepted Safety Case (as per the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 • mutual aid memorandum of understanding for relief well drilling is in place • accepted WOMP as per the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011. • notification of reportable and recordable incidents to NOPSEMA, if required, in accordance with Section 7. • objectives in the Ningaloo management plans (Management Plan for Ningaloo Marine Park and Muiron Islands Marine Management Areas, Ningaloo Marine Park Management Plan) with regards to water quality, coral, shoreline and intertidal, macroalgal, seagrass, mangroves, seabirds and social and economic values.

Environmental Performance Outcomes, Standards and Measurement Criteria

Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 12 Well loss of containment risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 12.1** Maintain well mechanical integrity to contain reservoir fluids within the well envelope to avoid a MEE.	**PS 12.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical PSs to prevent environment risk related damage to SCEs for: • P10 – Wells to: – ensure that a well retains the mechanical integrity to contain reservoir fluids within the well envelope at all times to avoid a MEE. Including operate phase environmentally critical equipment for pressure containment, structures, monitoring and isolating	**MC 12.1** Records demonstrate implementation of SCE technical Performance Standard(s) and Safety Critical Element Management Procedure.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		systems associated with the well.	
	C 12.2 Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies.	**PS 12.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • E04 – Safety Critical Communications to: – allow effective Emergency Response (ER) communications in emergencies, including: o internal communications such as audible and visual warning systems and voice communications during emergency events o external communications such as voice communications to adjacent facilities, aircraft and vessels, and external incident control centres during emergency events.	Refer to **MC 12.1**
	C 12.3 Maintain Safety Instrumented System (safety instrumented functions and emergency shutdown actions) to detect and respond to predefined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition so as to prevent or mitigate the effects of a MEE.	**PS 12.3** Integrity will be managed in accordance with SCE Management Procedure (Section 6.1.5.2) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F06 – Safety Instrumented System and P10 – Wells to together: – detect and respond to predefined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition so as to prevent or mitigate the effects of a MEE.	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	C 12.4 Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	**PS 12.4** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • E05 – Environmental Incident Response Equipment, including; – satellite tracking drifter buoy able to monitor spill movement – sufficient hydrocarbon spill response equipment for control and/or clean-up of liquid hydrocarbon spills to ocean – minimum equipment coverage, to maintain adequate spill response capability.	Refer to **MC 12.1**
	C 12.5 Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011: Accepted WOMP to demonstrate that the risks to well integrity are managed in accordance with sound engineering principles, standards, specifications, and good oilfield practice. It describes the systems that are in place to ensure well design and integrity is managed for the well lifecycle, thus contributing to management of associated potential environmental consequences of well integrity events.	**PS 12.5** An accepted WOMP is implemented, and well integrity notification and reporting is undertaken in accordance with the Regulations (as applicable).	**MC 12.5** Acceptance letter from NOPSEMA demonstrates acceptance of the WOMP. Records demonstrate applicable NOPSEMA notification and reporting.
	C 12.6 Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009:	**PS 12.6** An accepted Safety Case is implemented, and safety notification and reporting is undertaken in accordance with the Regulations (as applicable).	**MC 12.6** Acceptance letter from NOPSEMA demonstrates acceptance of the Safety Case. Records demonstrate applicable NOPSEMA notification and reporting.

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	• Accepted Safety Case for the Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.		
	C 8.5 Refer Section 6.7.1	**PS 8.5** Refer Section 6.7.1	**MC 8.5** Refer Section 6.7.1
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.4 Unplanned Hydrocarbon Release: Subsea Equipment Loss of Containment (MEE-02)

Context		
Flowline and Risers – Section 3.5.3 Subsea Infrastructure– Section 3.5.3 Subsea Inspection, Maintenance and Repair Activities – Section 3.10	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary														
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Release of hydrocarbons resulting from subsea equipment loss of containment.	-	X	X	X	X	X	X	B	C	2	M	LCS GP PJ RBA CV SV	Acceptable if ALARP	EPO 13

Description of Source of Risk

Background

The subsea production system comprises wells linked to subsea manifolds via flexible jumper and spool tie-ins. The subsea manifolds are then connected via flexible flowlines, which are tied back to the FPSO through five flexible risers (three production, one gas lift, one gas export). Gas is exported from the facility through a flexible riser from the RTM to a riser base where it connects to an 8-inch diameter flexible flowline, ~420 m long. The 8-inch flexible flowline connects to the Wanaea pipeline end (WANPE) module via a hydraulically operated subsea isolation valve. A 20 m rigid steel spool piece is located after the WANPE, which links to the 12-inch concrete coated WC GEL.

The hazard associated with this MEE is liquid hydrocarbons conveyed in Okha FPSO subsea equipment (flowlines, risers and associated equipment). The MEE associated with this hazard is loss of containment from the largest inventory subsea production flowline, resulting in a liquid hydrocarbon release to the environment. A loss of containment from a single riser does not result in a MEE due to a lower volume in the event of a spill, compared to a loss of containment from the largest inventory subsea production flowline.

A loss of subsea production flowline containment could occur because of:

- internal corrosion
- external corrosion
- overpressure
- underpressure
- equipment fatigue (risers and structural supports)
- pipeline stability and freespans
- anchor impact / dragging
- loss of control of suspended load from visiting vessel.

Escalation from other MEEs can cause subsea equipment loss of containment:

- loss of structural integrity (MEE-06) (Section 6.8.8)
- loss of marine vessel separation (MEE-07) (Section 6.8.9)
- loss of control of suspended load from facility lifting operations (MEE-08) (Section 6.8.10).

A number of common failure causes due to human error and SCE failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

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Context

Subsea Equipment Loss of Containment – Credible Scenario

The worst-case credible hydrocarbon release scenario is rupture of the 8-inch production flowline, which holds the largest liquid hydrocarbon inventory within the Okha subsea system. This could result in a release of up to 414 m^3 of oil, based on an instantaneous full bore release, before wells are shut in within (conservatively) one hour of the rupture event. After the wells are shut in, it is assumed that remaining oil within the flowline continues to be released gradually to seabed for 72 hours. Rupture location is assumed to be near the Lambert Hermes manifold (LHM) which is the lowest point of the 8-inch production line. The subsea equipment loss of containment scenario parameters are summarised in Table 6-24.

Table 6-24: Summary of worst-case subsea loss of containment hydrocarbon release scenario

Scenario	Hydrocarbon	Duration (hrs)	Depth (m)	Latitude (WGS84)	Longitude (WGS84)	Total Oil Release Volume
Rupture of 8-inch production flowline (near LHM)	Cossack light crude	72	95	19° 30' 48.75" S	116° 28' 8.07" E	414 m^3

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in subsea system design and construction. In the company's recent history, it has not experienced any subsea integrity events that have resulted in significant environmental impacts. The Okha FPSO has never experienced a worst-case subsea loss of containment in its operational history.

Decision Type

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications if the event is 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 2.7.3) and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The release of hydrocarbons as a result of subsea equipment loss of containment is considered a Major Environment Event (MEE-02). The hazard associated with this MEE is liquid hydrocarbons conveyed in Okha FPSO subsea equipment (flowlines, risers and associated equipment). Note that Woodside has assessed the environment consequence of a worst-case credible loss of containment from subsea equipment as 'C' as per the Woodside Risk Matrix. Woodside has also assessed the reputational and brand consequences associated with this release and concluded that the event results in a 'B' level consequence, and hence meets Woodside's definition of a MEE (refer to Section 2.7.2).

Quantitative Spill Risk Assessment

Spill modelling of a larger volume (773 m^3) of Cossack light crude, at the same location and depth in Table 6-24, was undertaken previously by RPS APASA, on behalf of Woodside, to determine the fate of hydrocarbon released in a worst-case credible subsea equipment loss of containment scenario. The modelled release volume (773 m^3) was based on rupture of both the 8-inch production flowline and 6-inch dual purpose flowline. Since undertaking this modelling, the 6-inch dual purpose line has been converted to gas lift. Hence, current worst-case credible hydrocarbon release scenario considers rupture of the 8-inch production flowline only. This previous modelling is considered appropriate and conservative to inform spill risk assessment for the current scenario outlined in Table 6-24.

Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the EMBA and the potential impacts from the identified worst-case credible release volumes for all subsea loss containment scenarios.

Refer to Section 6.8.1 for quantitative spill risk assessment methodology and Section 6.8.1.1 for a description of Cossack light crude characteristics.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, flowline marked on marine charts), the likelihood of a subsea loss of containment has been defined as Unlikely (2).

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case subsea equipment loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS,

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Context
available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure.

Consequence Assessment
Environment that May be Affected
Surface Hydrocarbons
The modelled surface hydrocarbons are forecast to drift down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time and may extend up to 15 km from the release site. Modelling results indicate no contact with sensitive receptors by surface (floating) hydrocarbons above the impact threshold (10 g/m^2) at probabilities of 1% or greater.
Entrained Hydrocarbons
Modelling results indicate no contact with sensitive receptors by entrained hydrocarbons above impact the threshold (400 ppb) at probabilities of 1% or greater.
Dissolved Hydrocarbons
Modelling results indicate no contact with sensitive receptors by dissolved hydrocarbons above the impact threshold (400 ppb) at probabilities of 1% or greater.
Accumulated Hydrocarbons
Modelling results indicate no contact with sensitive receptors by accumulated shoreline hydrocarbons above the impact threshold (100 g/m^2) at probabilities or 1% of greater, with a maximum accumulated volume of <1 m^3 along all shoreline receptors.
Consequence Assessment Summary
Modelling of the credible worst-case hydrocarbon spill scenario that may arise from MEE-02 indicates that the spill will remain offshore with contact limited to the Ancient Coastline at 125 m Depth Contour KEF, which overlaps the Operational Area. The biological consequences of such a spill on identified open water sensitive receptors relate to the potential for moderate, medium-term impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3).

MEE-02 Subsea Equipment Loss of Containment – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-02; refer to refer to Figure 6-10, Figure 6-11, Figure 6-12, and Figure 6-13.

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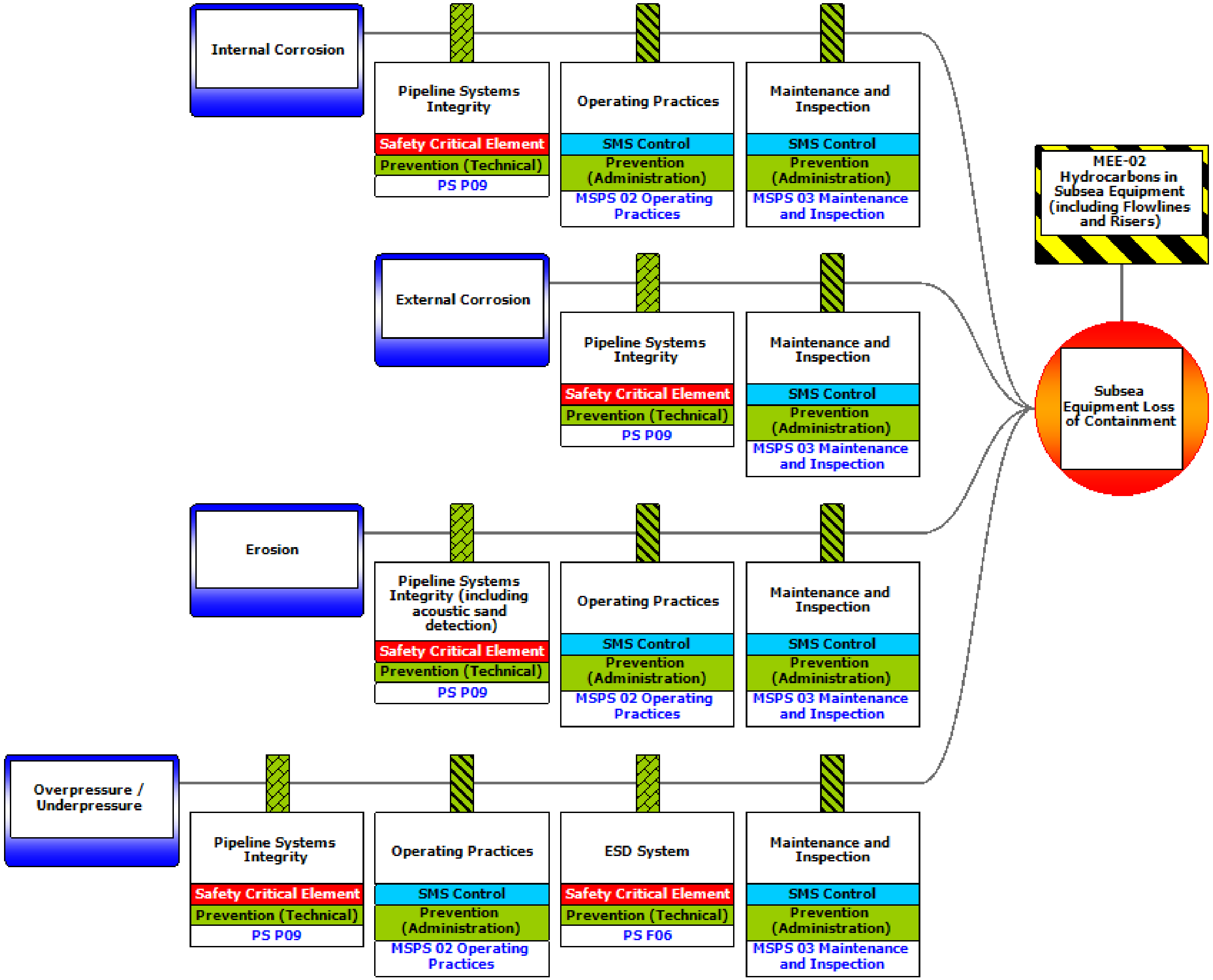

Figure 6-10: MEE-02 Subsea Equipment Loss of Containment (Causes 1–4)

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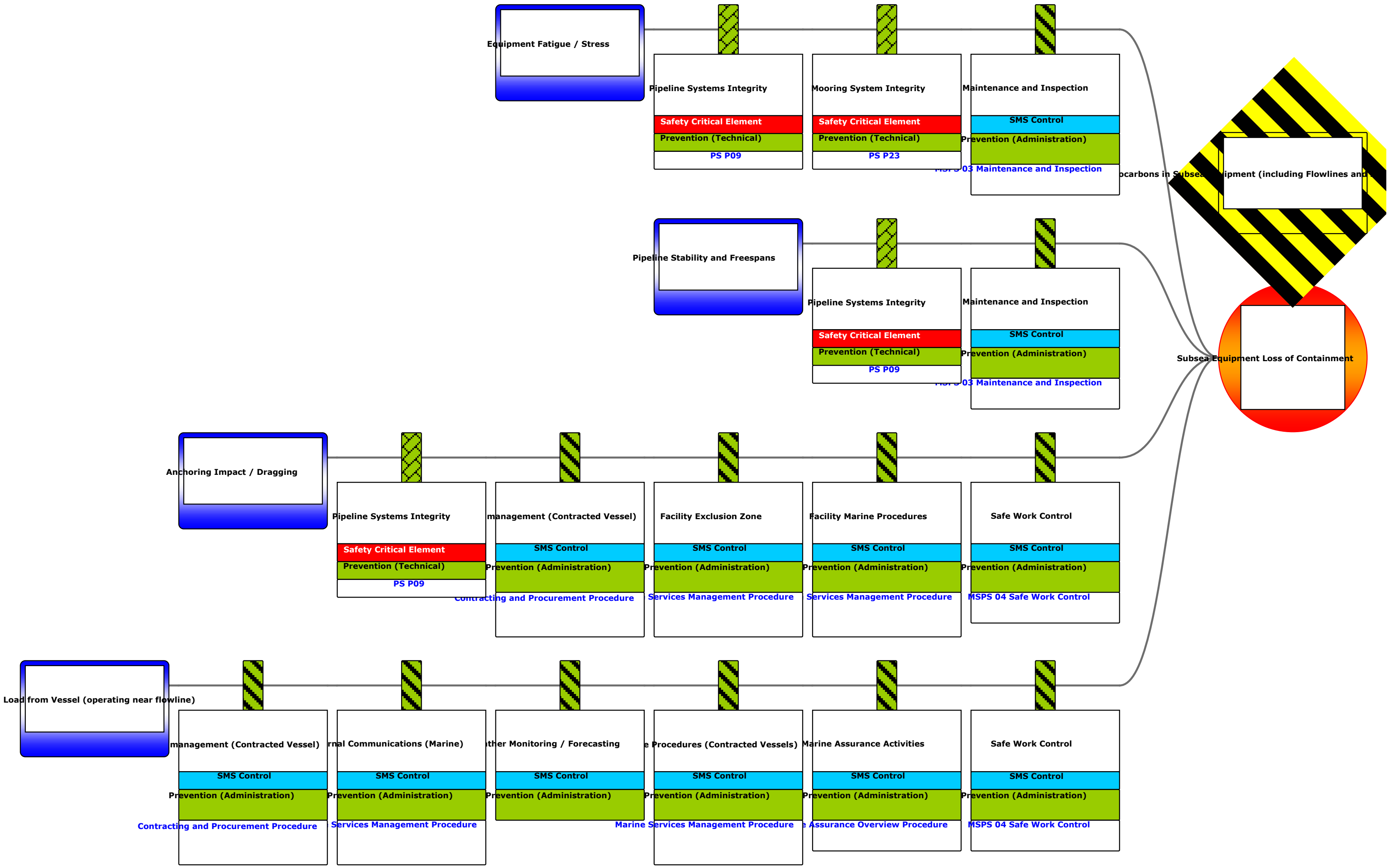

Figure 6-11: MEE-02 Subsea Equipment Loss of Containment (Causes 5–8)

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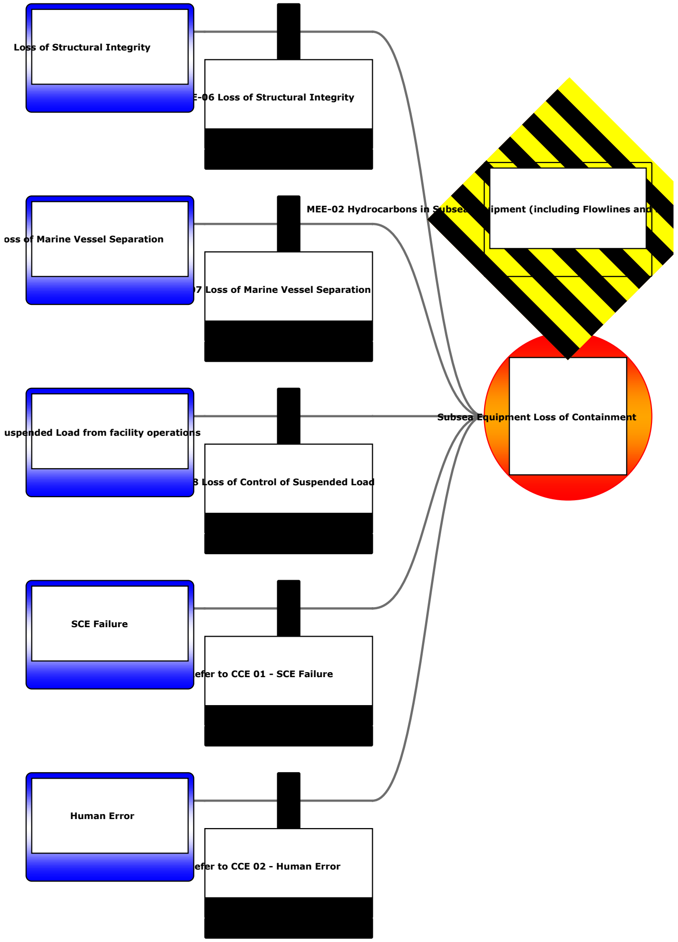

Figure 6-12: MEE-02 Subsea Equipment Loss of Containment (Causes 9–13)

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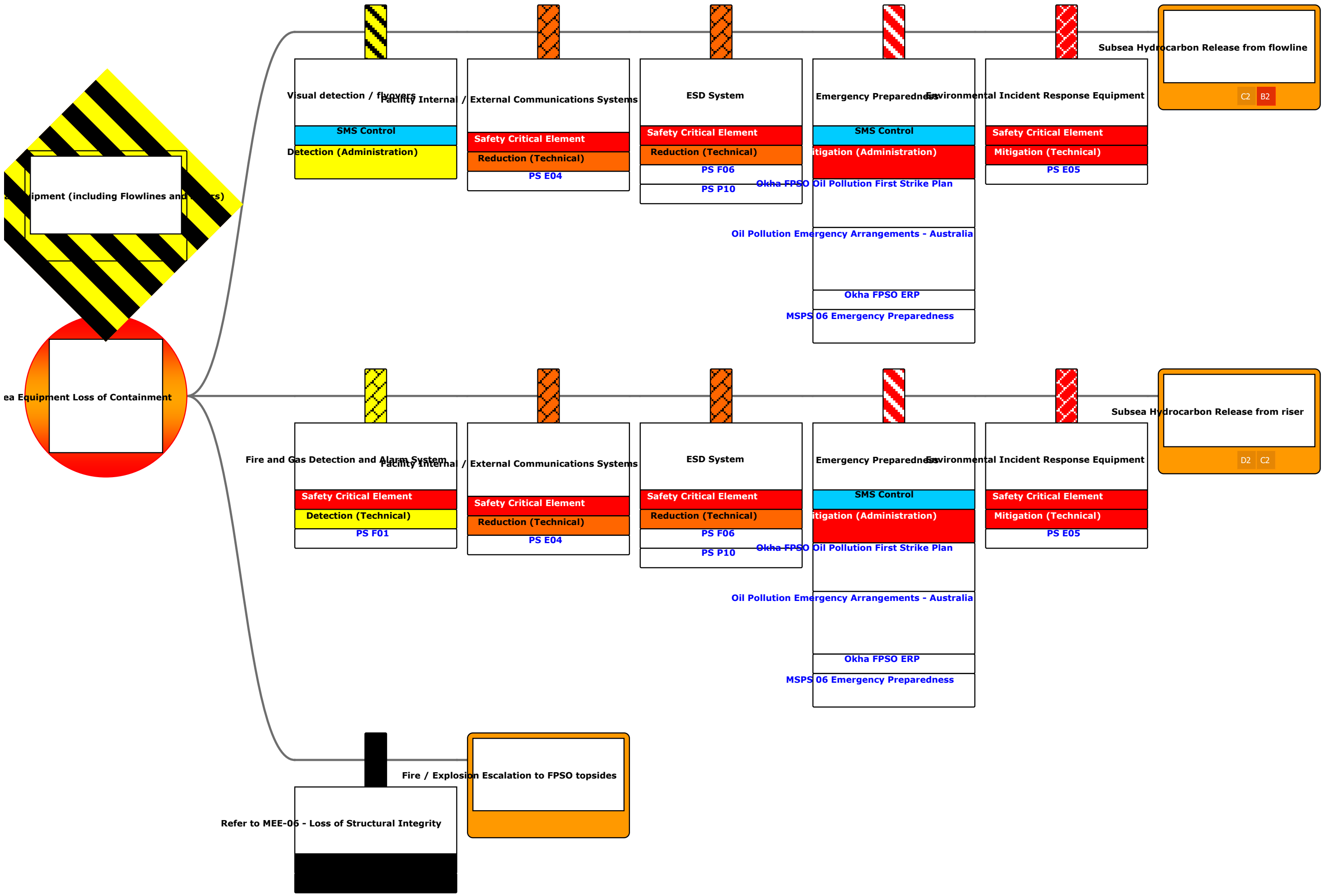

Figure 6-13: MEE-02 Subsea Equipment Loss of Containment (Outcomes)

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MEE-02 Subsea Equipment Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain flowline, riser and hydrocarbon-containing infrastructure integrity to avoid a MEE.	P09 – Pipeline Systems P23 – Mooring Systems F06 – Safety Instrumented System	Prevention (Technical)	Yes **C 13.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies.	E04 – Safety Critical Communications	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain Fire and Gas Detection and Alarm Systems to facilitate prevention and response to fire or gas hazards.	F01 – Fire and Gas Detection and Alarm System	Detection (Technical)	Yes **C 13.2**
Engineering Controls	Maintain Safety Instrumented System (Safety Instrumented Functions and emergency shutdown actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant, equipment, and the wells in a safe condition (e.g. through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE.	F06 – Safety Instrumented System P10 – Wells	Reduction / Control (Technical)	Yes **C 12.3**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks and	Okha FPSO Safety Case	Prevention / Mitigation (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**

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MEE-02 Subsea Equipment Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	– describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.			
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • M02 Operating Practices • M03 Maintenance and Inspections • M04 Safe Work Control • Marine Services Management Procedure • Marine Assurance Overview Procedure • Contracting and Procurement Procedure	MSPS-02 Operating Practices MSPS-03 Maintenance and Inspections MSPS-04 Safe work Control Marine Services Management Procedure Marine Assurance Overview Procedure Contracting and Procurement Procedure	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and contingency planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan	MSPS-06 Emergency Preparedness Okha Emergency Response Plan Okha Oil Pollution First Strike Plan (Appendix H)	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the ALARP

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MEE-02 Subsea Equipment Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	• Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia • Contracting and Procurement Procedure	Oil Pollution Emergency Arrangements – Australia Contracting and Procurement Procedure		assessment of controls related to hydrocarbon spill response.

Risk Based Analysis

For risks identified as MEEs, a more detailed risk-based Bowtie Analysis (as outlined in Section 2.7.3), has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside Risk Management Procedures, and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-02; refer to Figure 6-10, Figure 6-11, Figure 6-12, and Figure 6-13 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer Section 6.8.1 for details of spill modelling methodology).

Company Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

Societal Values

Refer to Societal Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a low likelihood unplanned hydrocarbon release as a result of a worst-case loss of subsea equipment containment.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of subsea equipment integrity and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures, and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

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MEE-02 Subsea Equipment Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Given the controls in place to prevent and control loss of containment events and mitigate their consequences, alongside procedural controls, it is considered that MEE risks associated with loss of containment from subsea equipment are managed to ALARP.				

Demonstration of Acceptability
Acceptability Statement Subsea equipment loss of containment has been evaluated as having a 'Moderate' risk rating. As per Section 2.8.2, Woodside considers 'Moderate' risk ratings as acceptable if ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained. Acceptability is demonstrated with regard to the considerations described for MEE-01 (Section 6.8.3), where considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 13 Subsea equipment loss of containment risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 13.1** Maintain flowline, riser and hydrocarbon-containing infrastructure integrity to avoid a MEE.	**PS 13.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P09 – Pipeline Systems • P23 – Mooring Systems • F06 – Safety Instrumented System to together: • maintain the minimum required mechanical and structural integrity to prevent loss of containment that may result in a MEE • detect and respond to pre-defined initiating conditions to protect mechanical integrity.	**MC 12.1**
	Refer to **C 12.2**	Refer to **PS 12.2**	Refer to **MC 12.1**
	Refer to **C 12.3**	Refer to **PS 12.3**	Refer to **MC 12.1**
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	C 13.2 Maintain Fire and Gas Detection and Alarm Systems to facilitate prevention and response to fire or gas hazards.	**PS 13.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for:	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		• F01 – Fire and Gas Detection and Alarm System; to continuously monitor and alert for fire events and significant gas accumulations, initiate actions to minimise event escalation, and support Emergency Response by providing status of situation.	
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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

Context		
Topsides – Section 3.5.1 Process Description – Section 3.6.2 Hydrocarbon and Chemical Inventories and Selection – Section 3.9	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release from topside process equipment to the marine environment and atmosphere.	-	-	X	X	X	X	X	B	D	1	M	LCS GP PJ RBA CV	Acceptable if ALARP	EPO 14
Hydrocarbon release from topsides non-process equipment to the marine environment.	-	-	X	X	X	X	X	B	D	1	M			

Description of Source of Risk

Background

The Okha FPSO has a range of topsides process and non-process equipment within 11 pre-assembled modules. Release of process (i.e. gas and crude) and non-process hydrocarbons (of which diesel is the largest inventory) from the Okha topsides has the potential to release moderate quantities of hydrocarbons to the marine environment. Topsides process and non-process hydrocarbon inventories are provided in Section 3.9.

The following causes could lead to loss of containment from the Okha FPSO topsides:

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

Escalation from other MEEs can cause topsides loss of containment:

- loss of structural integrity (MEE-06) (Section 6.8.8)
- loss of marine vessel separation (MEE-07) (Section 6.8.9)
- loss of control of suspended load from facility lifting operations (MEE-08) (Section 6.8.10).

A number of common failure causes due to human error and Safety Critical Equipment (SCE) failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

Topsides Loss of Containment – Credible Hydrocarbon Spill Scenarios

For a process release, the worst credible scenario is defined as the loss of the entire inventory of the HP separator, which holds a maximum isolatable inventory of 113.5 m^3 of crude oil. This scenario assumes a large borehole release (such as major rupture or failure) where the inventory would be released in less than 10 minutes, and assumes that only the isolatable inventory of the process equipment is released due to activation of the emergency shutdown systems, thus limiting further release of hydrocarbons.

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Context
For a non-process release, the worst credible scenario is defined as the loss of the entire inventory of one diesel day tank, which holds a maximum inventory of 6 m^3 of diesel. Larger diesel inventories are stored on the Okha FPSO (refer Section 3.9) however with the exception of the diesel day tanks, all other diesel storage tanks are located below the main deck, and therefore not considered credible topsides loss of containment scenario. ***Decision Type, Risk Analysis and ALARP Tools*** Woodside has a good history of implementing industry standard practice in FPSO operation. In the company's 60-year history, it has not experienced any topsides integrity events that have resulted significant environmental impacts. The Okha facility has never experienced a worst-case topsides loss of containment in its operational history. Decision Type Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling (Section 6.8.1). Company values were also considered in the demonstration of ALARP and acceptability. Note that Woodside has assessed the environment consequence of a worst-case credible loss of containment from topsides equipment as 'D' as per the Woodside Risk Matrix, which does not meet Woodside's definition of a MEE. However, topsides loss of containment has been retained for clarity and to articulate key control measures to control or prevent escalation to other MEEs. Quantitative Spill Risk Assessment Hydrocarbon spill modelling for a 724 m^3 release of processed crude oil as a result of an FPSO offtake system loss of containment (MEE-04) is discussed in Section 6.8.6. The results of this modelling can be considered to be a very conservative estimate of the worst-case topsides process loss of containment of the HP separator, which holds a maximum isolatable inventory of 113.5 m^3 of crude oil. The potential impacts of the topsides process release are therefore discussed in Section 6.8.6 (MEE-04). Similarly, hydrocarbon spill modelling for a 105 m^3 release of diesel due to loss of marine vessel separation (MEE-07) is discussed in Section 6.8.9. The results of this modelling can be considered to be a very conservative estimate of the worst-case topsides non-process loss of containment of a diesel day tank, which holds 6 m^3 of diesel. The potential impacts of the topsides non-process release are therefore discussed in Section 6.8.9 (MEE-07). Hydrocarbon Characteristics Refer to Section 6.8.1.1 for both Cossack light crude and diesel characteristics. Consequence The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case topsides loss of containment. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure. Likelihood In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood of a worst-case topsides loss of containment has been defined as Highly Unlikely (1).

Consequence Assessment
Detailed assessment of the potential impacts from a hydrocarbon release from topside process and non-process equipment has been described in Section 6.8.6 (MEE-04) and Section 6.8.9 (MEE-07). Refer to Section 6.8.3 for a description of potential impacts. Impacts from the credible worst-case hydrocarbon spill scenario that may arise from MEE-03 have been inferred from modelling outputs described in Section 6.8.6 (MEE-04) and Section 6.8.9 (MEE-07). These conservative modelling results indicate that the spill will remain offshore with contact limited to the Ancient Coastline at 125 m Depth Contour KEF and the Glomar Shoal KEF. The biological consequences of such a spill on identified open water sensitive receptors relate to the potential for minor, short-term impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3).

MEE-03 Topsides Loss of Containment – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-03; refer to Figure 6-14, Figure 6-15, Figure 6-16, and Figure 6-17 for bowtie diagrams.

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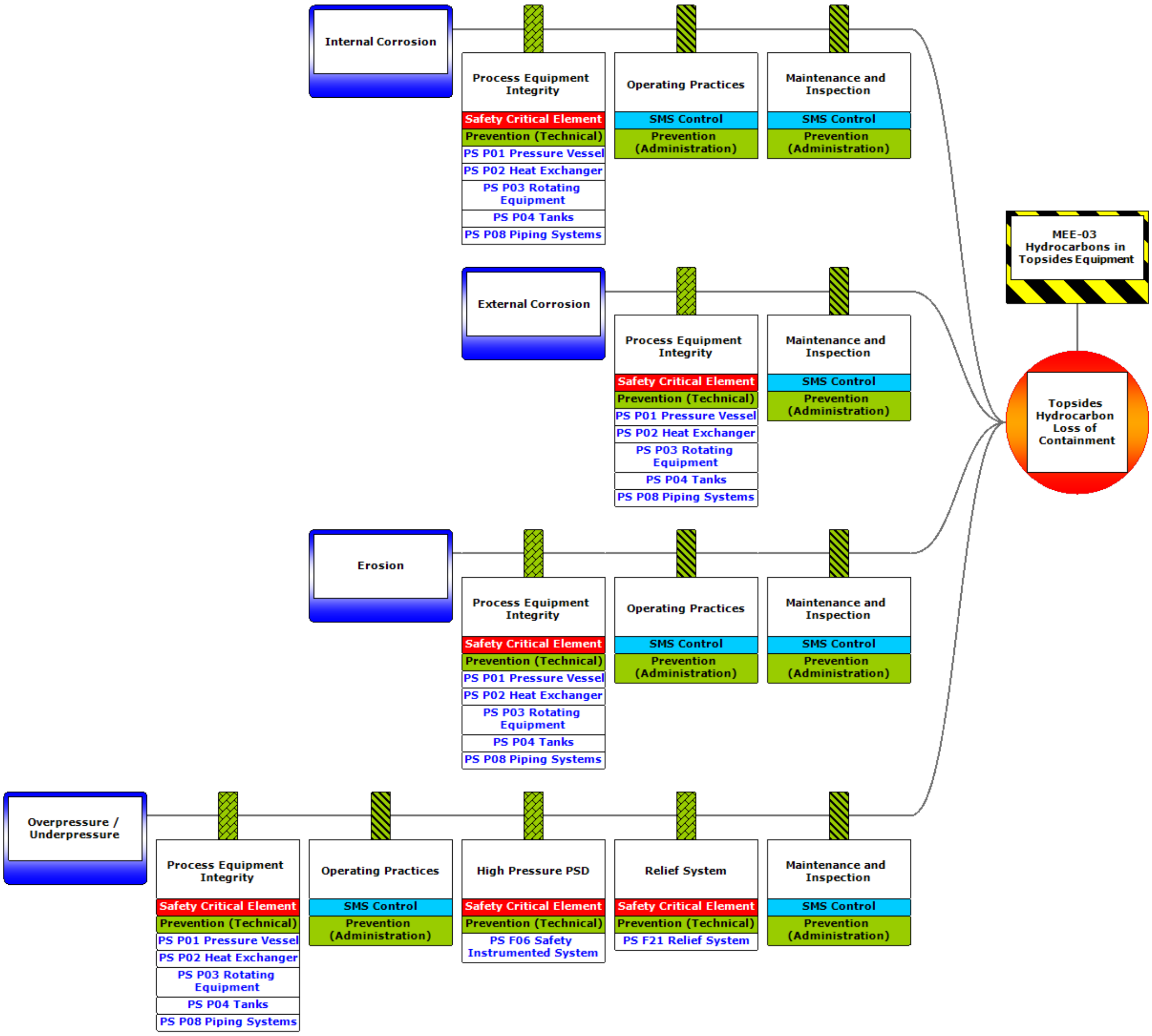

Figure 6-14: MEE-03 Topsides Loss of Containment (Causes 1–4)

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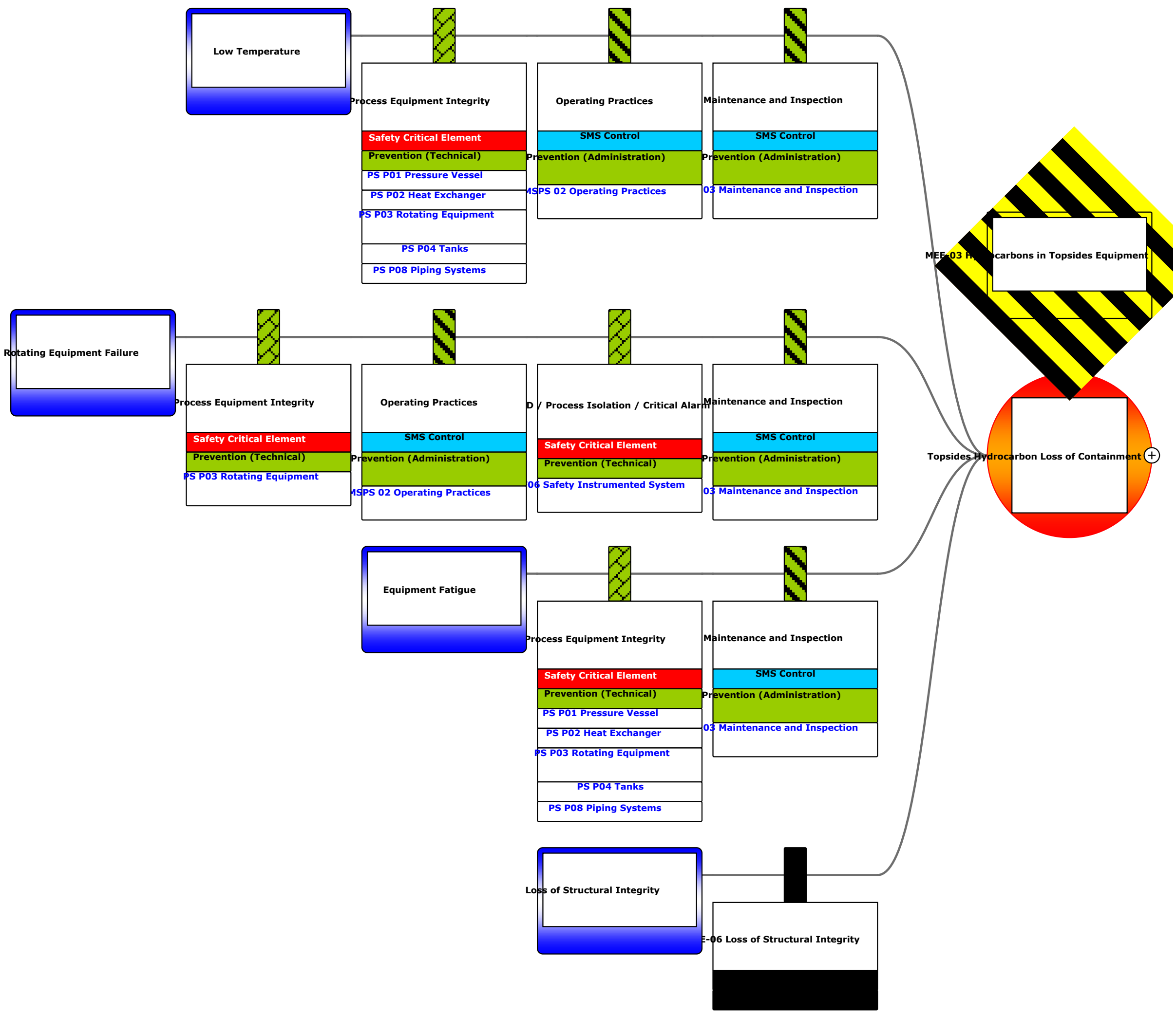

Figure 6-15: MEE-03 Topsides Loss of Containment (Causes 5–8)

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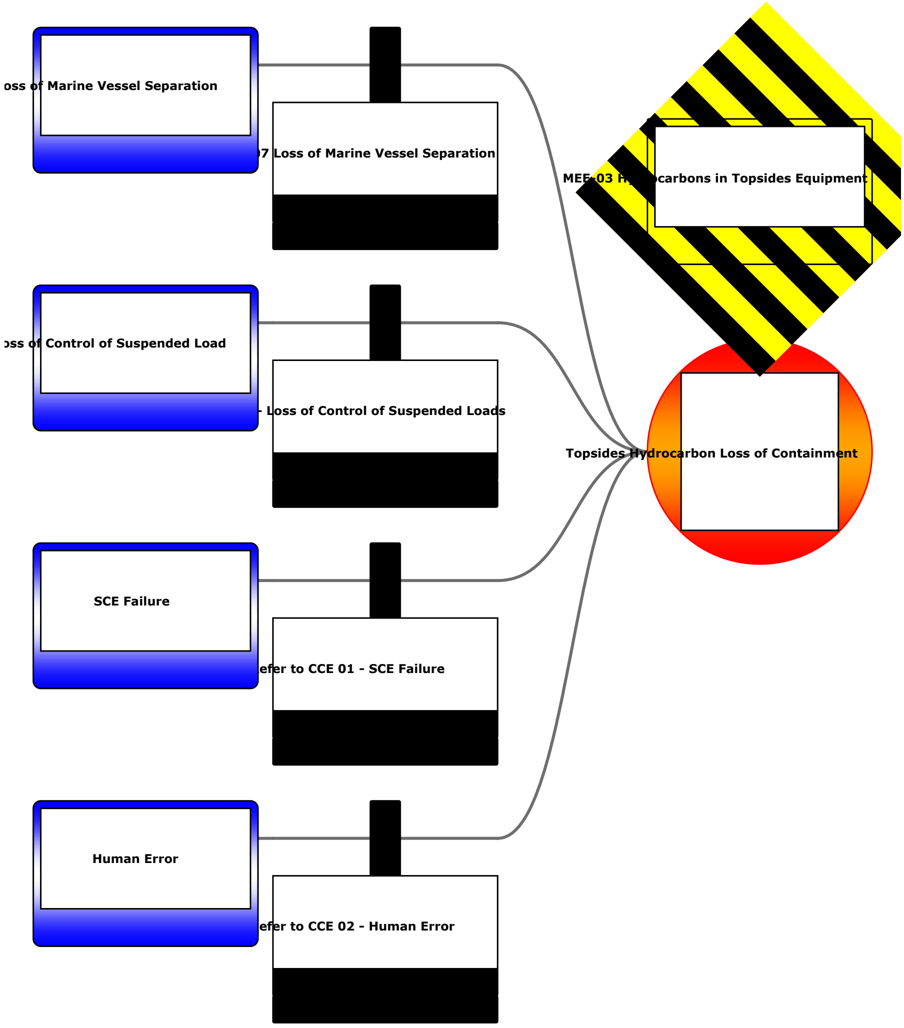

Figure 6-16: MEE-03 Topsides Loss of Containment (Causes 9–12)

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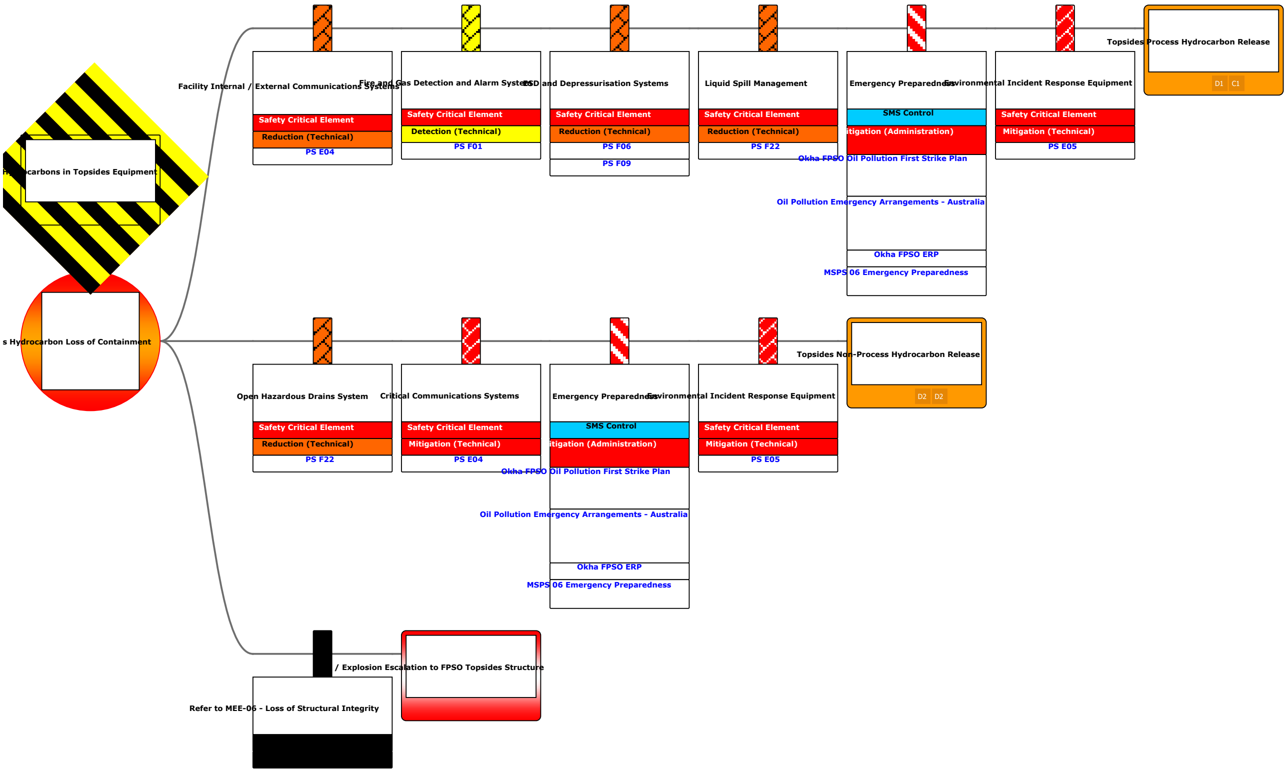

Figure 6-17: MEE-03 Topsides Loss of Containment (Outcomes)

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MEE-03 Topsides Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain topsides hydrocarbon-containing infrastructure integrity.	P01 – Pressure Vessel P02 – Heat Exchanger P03 – Rotating Equipment P04 – Tanks P08 – Piping Systems	Prevention (Technical)	Yes **C 14.1**
Engineering Controls	Maintain Safety Instrumented Systems and Relief System to prevent hydrocarbon loss of containment in order to prevent a MEE.	F06 – Safety Instrumented System F21 – Relief Systems	Prevention (Technical)	Yes **C 14.2**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies.	E04 – Safety Critical Communications	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain Fire and Gas detection and Alarm Systems on Okha facility to facilitate prevention and response to fire or gas hazards.	F01 – Fire and Gas Detection and Alarm System	Detection (Technical)	Yes **C 13.3**
Engineering Controls	Maintain Safety Instrumented Systems (e.g. emergency shutdown and safety instrumented functions) system, Blowdown and Open Hazardous Drains system to isolate, remove and control hazardous inventories so as to mitigate the effects of a MEE/ prevent escalation to a MEE.	F06 – Safety Instrumented System F09 – Depressurisation (Blowdown); F22 – Open Hazardous Drains	Reduction / Control (Technical)	Yes **C 13.2**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C12.4**

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MEE-03 Topsides Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	Pollution First Strike Plan (Appendix H).			
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports	Yes **C 8.5**

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<table>
<tr><th colspan="5">MEE-03 Topsides Loss of Containment – Demonstration of ALARP
ALARP Control Measures</th></tr>
<tr><th>Hierarchy</th><th>Control / Barrier</th><th>SCE / Management System Reference</th><th>Type of Effect (Table 6-21)</th><th>Control Adopted</th></tr>
<tr><td></td><td></td><td></td><td>compliance with regulatory reporting requirements.</td><td></td></tr>
<tr><td colspan="5">Management System Specific Measures: Key Standards or Procedures</td></tr>
<tr><td>Procedures and Administration</td><td>Implement management systems to maintain:
• M02 Operating Practices
• M03 Maintenance and Inspections
• Maintain Assets Procedure.</td><td>MSPS-02 Operating Practices
MSPS-03 Maintenance and Inspections
Maintenance of Assets Procedure</td><td>Prevention (Administration)</td><td>Yes – See Section 7 Implementation Strategy.</td></tr>
<tr><td>Emergency Response and contingency planning</td><td>Implement management systems to maintain:
• M06 – Emergency Preparedness
• Okha Emergency Response Plan
• Okha Oil Pollution First Strike Plan (Appendix H)
• Oil Pollution Emergency Arrangements – Australia.</td><td>MSPS 06 – Emergency Preparedness
Okha Emergency Response Plan
Okha Oil Pollution First Strike Plan (Appendix H)
Oil Pollution Emergency Arrangements – Australia</td><td>Mitigation
(Administration)</td><td>Yes – See Section 7
Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.</td></tr>
<tr><td colspan="5">Risk Based Analysis</td></tr>
<tr><td colspan="5">For risks identified as MEEs, a more detailed risk based Bowtie Analysis (as outlined in Section 2.7.1) has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.
Application of Woodside Risk Management Procedures, and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:
• ongoing hazard identification, risk assessment and the identification of control measures
• ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.
For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.
Bowtie analysis was undertaken to assess MEE-03; refer to Figure 6-14, Figure 6-15, Figure 6-16, and Figure 6-17 for bowtie diagrams.
A quantitative spill risk assessment was undertaken (refer Section 6.8.1).</td></tr>
<tr><td colspan="5">Company Values</td></tr>
<tr><td colspan="5">Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).</td></tr>
<tr><td colspan="5">Societal Values</td></tr>
</table>

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MEE-03 Topsides Loss of Containment – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Refer to Societal Values in demonstration of ALARP for MEE-01 (Section 6.8.3).				

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Highly Unlikely unplanned hydrocarbon release as a result of a loss of topsides containment.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of topsides integrity and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha FPSO Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures, and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, it is considered that MEE risk associated with topsides loss of containment at Okha is managed to ALARP.

Demonstration of Acceptability

Topsides loss of containment has been evaluated as having a 'Moderate' risk rating. As per Section 2.8.2, Woodside considers 'Moderate' risk ratings as broadly acceptable if the adopted controls are implemented. Due to the consequence associated with MEE-03, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained.

Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 14 Topsides loss of containment risks to the environment limited to Moderate through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 14.1** Maintain topsides hydrocarbon-containing infrastructure integrity.	**PS 14.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: P01 – Pressure Vessel P02 – Heat Exchanger P03 – Rotating Equipment	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		P04 – Tanks P08 – Piping Systems; to together: • provide minimum required mechanical integrity for identified SCE systems (piping, heat exchangers, rotating equipment, and pressure vessel) for operation within defined integrity limits so as to prevent a loss of containment that may result in a MEE.	
	C 14.2 Maintain Safety Instrumented Systems and Relief System to prevent hydrocarbon loss of containment in order to prevent a MEE.	**PS 14.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F06 – Safety Instrumented System to: – detect and respond to pre-defined initiating conditions to protect mechanical integrity and prevent loss of containment (including uncontrolled diesel transfer/overflow) • F21 – Relief Systems to: – protect pressurised equipment, equipment exposed to high pressures and piping from a loss of containment to prevent escalation to a MEE.	Refer to **MC 12.1**
	Refer to **C 12.2**	Refer to **PS 12.2**	Refer to **MC 12.1**
	Refer to **C 13.2**	Refer to **PS 13.2**	Refer to **MC 12.1**
	C 14.3 Maintain Safety Instrumented Systems (e.g. emergency shutdown and safety instrumented functions) system, Blowdown and Open Hazardous Drains system to isolate, remove and control hazardous inventories so as to mitigate the effects of a MEE/ prevent escalation to a MEE.	**PS 14.3** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F06 – Safety Instrumented System to: – detect and respond to pre-defined initiating conditions and initiate responses that function to put the process plant,	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		equipment, and the wells in a safe condition through appropriate isolation of hazardous inventories so as to prevent or mitigate the effects of a MEE. • F09 – Depressurisation (Blowdown) to: – safely depressurise the installation in order to avoid, or minimise the escalation of an uncontrolled loss of containment. • F22 – Open Hazardous Drains to: – prevent escalation of an incident following loss of containment, fire and/or explosion by removing or containing flammable liquid from hazardous areas; and – support appropriate containment and disposal of environmentally hazardous liquids to avoid damage to the environment.	
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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

Context		
Offtake System and Offtake Tanker Mooring – Section 3.6.6	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release from Okha FPSO offtake equipment to the marine environment and atmosphere.	-	X	X	-	X	X	X	B	C	1	M	LCS GP PJ RBA CV SV	Acceptable if ALARP	EPO 15

Description of Source of Risk

Background

Stabilised crude product is transferred to a tandem moored offtake tanker via the stern mounted offtake hose. The Okha FPSO uses a standard ship's cargo pump arrangement (two pumps at 2000 m^3/h each) to manage and offload crude cargo. The Okha FPSO has an operational storage capacity of 934,000 bbl of oil.

In the event of an emergency on either the Okha FPSO or the offtake tanker during an offtake, the tanker would be released via a quick release of the hawser at the stern of the FPSO. This hook is either remotely activated or manually released via a nearby lever. The offtake system is equipped with a dry breakaway coupling which will release at a predetermined tension preventing significant damage to the offtake hose whilst minimising oil spillage.

The following causes could lead to loss of containment from the FPSO offtake system:

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

Escalation from other MEEs could cause loss of containment from the FPSO offtake system:

- loss of structural integrity (MEE-06) (Section 6.8.8)
- loss of marine vessel separation (MEE-07) (Section 6.8.9)
- loss of control of suspended load from facility lifting operations (MEE-08) (Section 6.8.10).

Offtake Equipment Loss of Containment – Credible Hydrocarbon Spill Scenarios

The worst-case credible scenario for an offtake loss of containment modelled is considered to be ~724 m^3 of crude oil, which includes the loss of the entire inventory of the offtake hose and the release associated with continued pumping at the maximum rate of 4000 m^3 oil per hour for 10-minutes. This scenario assumes the 24-hour watch would not immediately identify the incident, and instead assumes a worst-case credible time of 10-minutes for detection and then activation/actuation of shutdown systems. The characteristics of the offtake equipment loss of containment scenario are summarised in Table 6-25.

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Table 6-25: Summary of the worst-case offtake equipment loss of containment release scenario

Scenario	Hydrocarbon	Duration (minutes)	Depth (m)	Latitude (WGS84)	Longitude (WGS84)	Total Crude Release Volume (m^3)
Offtake equipment loss of containment	Cossack (Okha) light crude	10	Surface	19° 35’ 21” S	116° 26’ 48” E	724 m^3

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO operation. In the company’s 60-year history, it has not experienced any offtake events that have resulted significant environmental impacts. The Okha facility has never experienced a worst-case offtake loss of containment in its operational history.

Decision Type

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling (Section 6.8.1). Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons from an offtake equipment loss of containment is considered a MEE (MEE-04). The hazard associated with this MEE is hydrocarbons contained within the offtake equipment. Note that Woodside has assessed the environment consequence of a worst-case credible loss of containment from offtake equipment as ‘C’ as per the Woodside Risk Matrix. Woodside has also assessed the reputational and brand consequences associated with this release and concluded that the event results in a ‘B’ level consequence, and hence meets Woodside’s definition of a MEE (refer to Section 2.7.2).

Quantitative Spill Risk Assessment

Stochastic spill modelling of worst-case credible offtake equipment loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulation was a 10-minute release based on the assumptions in Section 6.8.1. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the EMBA and the potential impacts from the identified worst-case credible release volume for an offtake equipment loss of containment.

Hydrocarbon Characteristics

Refer to Section 6.8.1.1 for Cossack light crude characteristics.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case offtake equipment loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood of a worst-case topsides loss of containment has been taken as Highly Unlikely (1).

Consequence Assessment

Environment that May Be Affected

Surface Hydrocarbons

The modelled surface hydrocarbons are forecast to drift down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time, and may extend up to 65 km from the release site. Modelling results indicate no contact with sensitive receptors by surface (floating) hydrocarbons above the impact threshold (10 g/m^2) at probabilities of 1% or greater.

Entrained Hydrocarbons

Modelling results indicate no contact with sensitive receptors by entrained hydrocarbons above impact the threshold (400 ppb) at probabilities of 1% or greater.

Dissolved Hydrocarbons

Modelling results indicate no contact with sensitive receptors by dissolved hydrocarbons above the impact threshold (400 ppb) at probabilities of 1% or greater.

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Consequence Assessment
<u>Accumulated Hydrocarbons</u> Modelling results indicate no contact with sensitive receptors by accumulated shoreline hydrocarbons above the impact threshold (100 g/m^2) at probabilities or 1% of greater, with a maximum accumulated volume of <1 m^3 along all shoreline receptors. ***Consequence Assessment Summary*** Modelling of the credible worst-case hydrocarbon spill scenario that may arise from MEE-04 indicates that the spill will remain offshore with contact limited to the Ancient Coastline at 125 m Depth Contour KEF and the Glomar Shoal KEF. The biological consequences of such a spill on identified open water sensitive receptors relate to the potential for moderate, medium-term impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill affected area. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3).

MEE-04 Offtake Equipment Loss of Containment – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-04; refer to Figure 6-18, Figure 6-19, Figure 6-20, and Figure 6-21 for bowtie diagrams.

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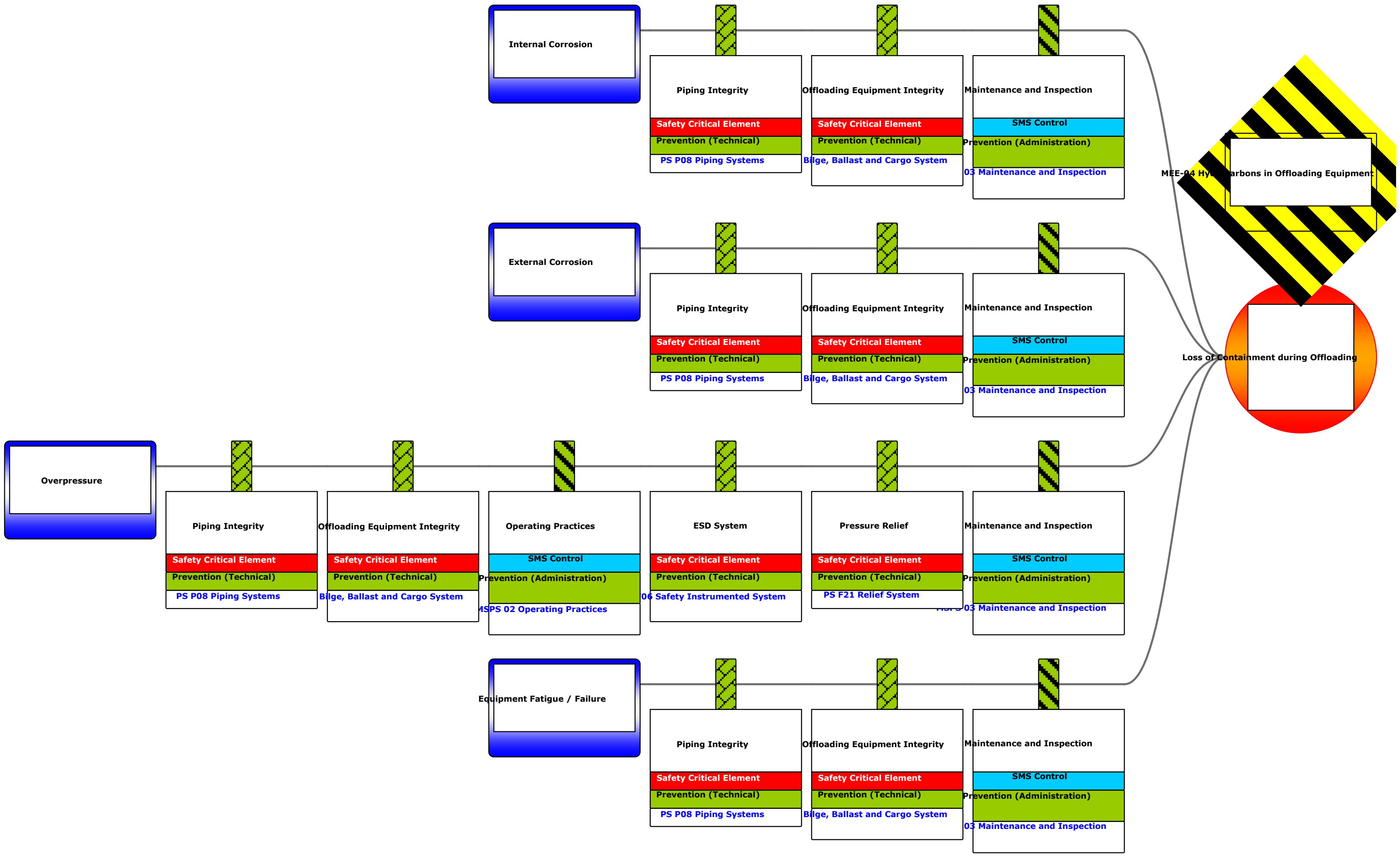

Figure 6-18: MEE-04 Offtake Loss of Containment (Causes 1–4)

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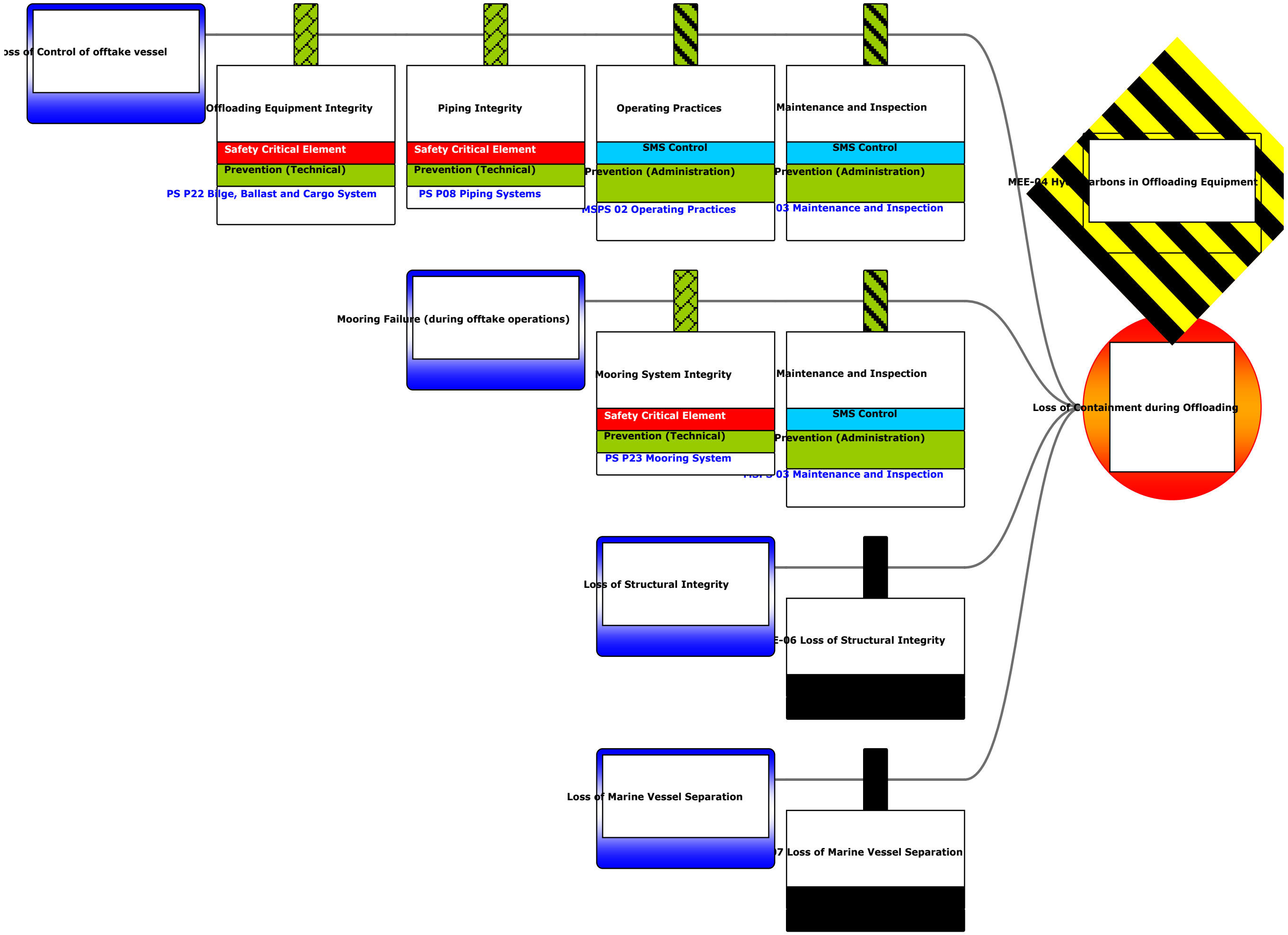

Figure 6-19: MEE-04 Offtake Loss of Containment (Causes 5–8)

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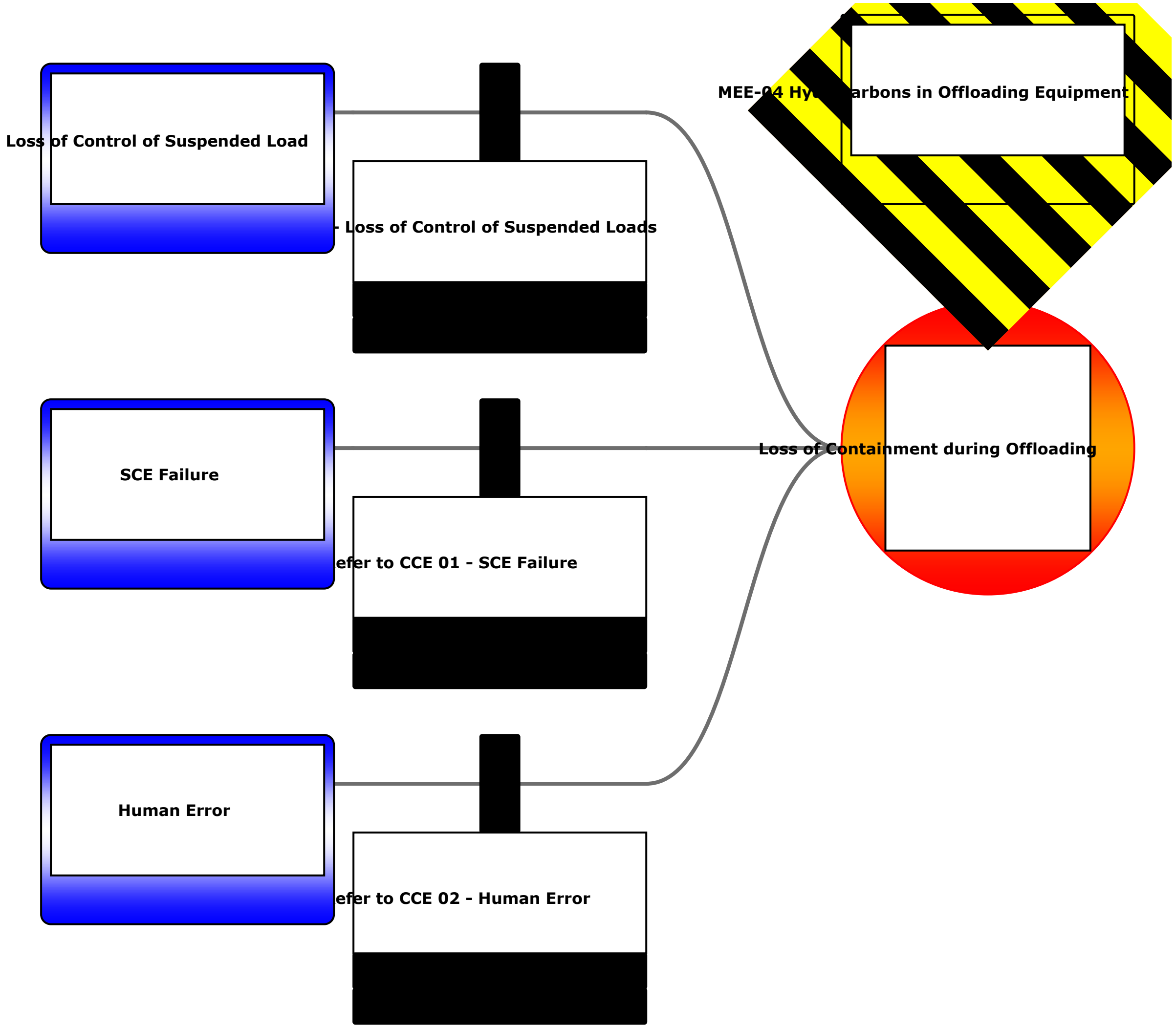

Figure 6-20: MEE-04 Offtake Loss of Containment (Causes 9–11)

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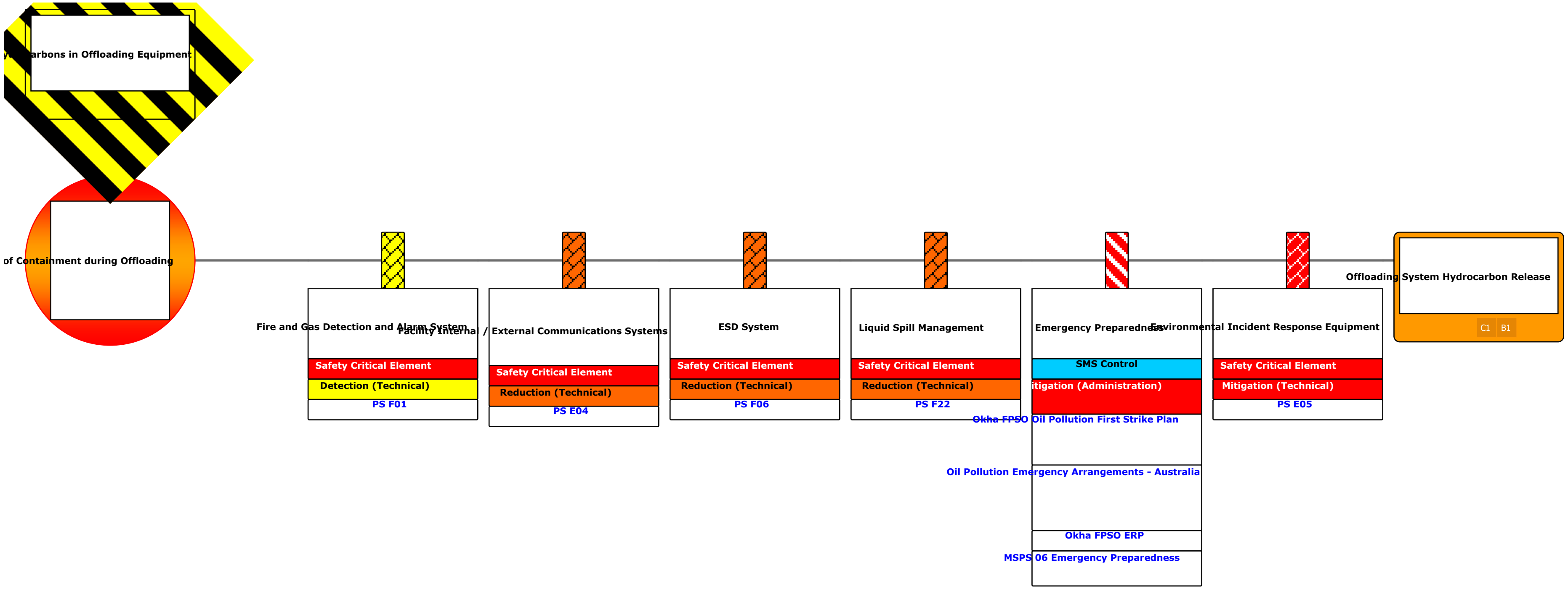

Figure 6-21: MEE-04 Offtake Loss of Containment (Outcomes)

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MEE-04 Offtake Equipment Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain offtake equipment hydrocarbon-containing infrastructure integrity.	P08 – Piping Systems P22 – Bilge, Ballast and Cargo Systems P23 – Mooring Systems F06 – Safety Instrumented System F21 – Relief Systems	Prevention (Technical)	Yes **C 15.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies.	E04 – Safety Critical Communications	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain Fire and Gas detection and Alarm Systems on Okha facility to facilitate prevention and response to fire or gas hazards.	F01 – Fire and Gas Detection and Alarm System	Detection (Technical)	Yes **C 13.2**
Engineering Controls	Maintain Safety Instrumented System (Safety Instrumented Functions and emergency shutdown actions) to detect and respond to predefined initiating conditions and/or initiate responses that put the process plant and equipment in a safe condition (e.g. through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE.	F06 – Safety Instrumented System	Reduction / Control (Technical)	Yes **C 15.2**
Engineering Controls	Maintain stability and reduce hull stresses during offtake to prevent or mitigate an MEE.	P22 – Bilge, Ballast and Cargo Systems	Mitigation (Technical)	Yes **C 15.3**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C12.4**

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MEE-04 Offtake Equipment Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain:	MSPS-02 Operating Practices	Prevention (Administration)	Yes – See Section 7

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MEE-04 Offtake Equipment Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	• M02 Operating Practices • M03 Maintenance and Inspections.	MSPS-03 Maintenance and Inspections		Implementation Strategy.
Procedures and Administration	Implement offtake procedures: • Offtake Tanker FPSO Compatibility Procedure; and • Tanker Assurance Procedure.	Offtake Tanker FPSO Compatibility Procedure Tanker Assurance Procedure	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and contingency planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	MSPS 06 – Emergency Preparedness Okha Emergency Response Plan Okha Oil Pollution First Strike Plan (Appendix H) Oil Pollution Emergency Arrangements – Australia	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.

Risk Based Analysis

For risks identified as MEEs, a more detailed risk-based Bowtie Analysis (as outlined in Section 2.7.3) has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-04; refer to Figure 6-18, Figure 6-19, Figure 6-20, and Figure 6-21 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer Section 6.8.1).

Company Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

Societal Values

Refer to Societal Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

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MEE-04 Offtake Equipment Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Highly Unlikely unplanned hydrocarbon release as a result of an offtake equipment loss of containment.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of the offtake system and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, it is considered that MEE risk associated with offtake equipment loss of containment at Okha is managed to ALARP.

Demonstration of Acceptability

Offtake equipment loss of containment has been evaluated as having a ‘Moderate’ risk rating. As per Section 2.8.2, Woodside considers ‘Moderate’ risk ratings as broadly acceptable if the adopted controls are implemented. Due to the consequence associated with MEE-04, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained.

Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 15 Offloading loss of containment risks to the environment limited to Moderate through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 15.1** Maintain offloading equipment hydrocarbon-containing infrastructure integrity.	**PS 15.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P08 – Piping Systems; to: – provide minimum required mechanical integrity for identified Safety and Environment Critical Piping so as to prevent a loss of containment that may result in an MEE (for operation within defined integrity limits). • P22 – Bilge, Ballast and Cargo Systems; to: – maintain hull stress and vessel stability within integrity limits. • P23 – Mooring Systems; to: – provide station keeping within allowable excursion envelope; – provide ability to disconnect facility from mooring on demand – provide ability to disconnect offtake tanker from facility on demand. • F06 – Safety Instrumented System; to: – detect and respond to pre-defined initiating conditions to protect mechanical integrity. • • F21 – Relief Systems; to: – protect pressurised equipment, equipment exposed to high pressures and piping from a loss of containment to prevent escalation to an MEE.	Refer to **MC 12.1**
	Refer to **C 12.2**	Refer to **PS 12.2**	Refer to **MC 12.1**
	Refer to **C 13.2**	Refer to **PS 13.2**	Refer to **MC 12.1**
	C 15.2 Maintain Safety Instrumented System (Safety Instrumented	**PS 15.2** Integrity will be managed in accordance with SCE Management Procedure	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	Functions and ESD actions) to detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant and equipment in a safe condition (e.g. through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of an MEE.	(Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F06 – Safety Instrumented System to: – detect and respond to pre-defined initiating conditions and/or initiate responses that put the process plant and equipment in a safe condition so as to prevent or mitigate the effects of an MEE.	
	C 15.3 Maintain stability and reduce hull stresses during offloading to prevent or mitigate an MEE.	**PS 15.3** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P22 – Bilge, Ballast and Cargo Systems to: – maintain hull stress and vessel stability within integrity limits.	Refer to **MC 12.1**
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.7 Unplanned Hydrocarbon Release: Cargo Tank Loss of Containment (MEE-05)

Context		
Cargo Tanks – Section 3.6.5	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	Environmental Value Potentially Impacted							Evaluation						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release caused by cargo tank loss of containment.	-	X	X	-	X	X	X	B	A	1	H	LCS GP PJ RBA CV SV	Acceptable if ALARP	EPO 16

Description of Source of Risk

Background

The Okha FPSO has a total of 11 dedicated cargo tanks which are designed to receive and store crude oil directly from topsides process plant. The crude oil is fed from the topsides directly to the cargo tanks by dedicated drop lines into the top of all cargo tanks. The individual storage tanks range in capacity, with a total operational storage capacity of 934,000 bbl of oil. A loss of containment from a cargo tank may result in a significant volume of crude being released to the marine environment. Due to the potential consequences, a cargo tank loss of containment is considered a MEE (MEE-05). The potential hazard sources that could instigate a cargo tank loss of containment are:

- corrosion
- overpressure or underpressure
- tank leakage/over filling
- equipment fatigue
- loss of containment between cargo tanks
- loss of cargo tank atmosphere control
- cargo tank vacuum.

Escalation from other MEEs could cause loss of containment from the FPSO cargo tanks:

- loss of structural integrity (MEE-06) (Section 6.8.8)
- loss of marine vessel separation (MEE-07) (Section 6.8.9)
- loss of control of suspended load from facility lifting operations (MEE-08) (Section 6.8.10).

FPSO Cargo Tank Loss of Containment – Credible Hydrocarbon Spill Scenarios

There is a credible worst-case loss of containment scenario caused by bulkhead damage resulting in the loss of two adjacent cargo tanks. As such, the worst-case credible loss of containment scenario from a cargo tank spill on the Okha FPSO is taken as 30,302 m^3 of crude. This volume is based on the assumption that the largest cargo tank and the next largest adjacent cargo tank both lost their entire inventory (standard loading limit – tank capacity at 98%). This scenario is considered conservative given that for the entire inventory to be lost from a tank, it would require the point of rupture to be such that the entire volume could drain freely from the tank to the environment (e.g. point of rupture would have to be at the bottom part of a tank). Whereas rupture from a vessel collision would be at the water line and thus at the upper side of the tank).

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A loss of containment of diesel fuel stored within the vessel hull due to vessel collision is also a credible event. The single largest inventory of diesel within the hull is the Port diesel Bunker Tank No.3 (1230 m^3). The cargo tank loss of containment event has been selected to inform the risk assessment due to the larger potential release volume. Release characteristics for cargo tank loss of containment scenario are summarised in Table 6-26.

Table 6-26: Summary of the worst-case cargo tank loss of containment release scenario

Scenario	Hydrocarbon	Duration (hours)	Depth (m)	Latitude (WGS84)	Longitude (WGS84)	Total Crude Release Volume (m^3)
Cargo tank loss of containment	Cossack (Okha) light crude	24 hours	Surface	19° 35' 21" S	116° 26' 48" E	30,302 m^3

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO operation. In the company's 60-year history, it has not experienced any cargo tank integrity events that have resulted significant environmental impacts. The Okha facility has never experienced a worst-case cargo tank loss of containment in its operational history.

Decision Type

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling (Section 6.8.1). Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons from an Okha FPSO cargo tank loss of containment is considered a MEE (MEE-05). The hazard associated with this MEE is hydrocarbons contained within the Okha FPSO cargo tanks.

Quantitative Spill Risk Assessment

Stochastic spill modelling of worst-case credible offtake equipment loss of containment scenario was undertaken by RPS APASA, on behalf of Woodside. The simulation was a phased release over 24 hours based on the assumptions in Section 6.8.1. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the EMBA and the potential impacts from the identified worst-case credible release volume for an Okha FPSO cargo tank loss of containment.

Hydrocarbon Characteristics

Refer to Section 6.8.1.1 for Cossack light crude characteristics.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case Okha FPSO cargo tank loss of containment (presented in the following section). These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood of a worst-case topsides loss of containment has been taken as Highly Unlikely (1).

Consequence Assessment

Environment that May Be Affected

Surface Hydrocarbons

Quantitative hydrocarbon spill modelling results for surface hydrocarbons are shown in Table 6-27. The modelled surface hydrocarbons are forecast to drift down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time, and may extend up to 292 km from the release site at concentrations above the impact threshold (10 g/m^2). Modelling results indicate a potential for contact by surface (floating) hydrocarbons above the impact threshold for the Montebello Islands (1% probability for AMP and State Marine Park). However, no other receptors were predicted to be contacted at probabilities of 1% or greater.

Entrained Hydrocarbons

Quantitative hydrocarbon spill modelling results for entrained hydrocarbons are shown in Table 6-27. Contact by entrained oil at concentrations equal to or above the impact threshold (400 ppb) is predicted at the Montebello Islands (18%), as well as at several other sensitive receptors with probabilities less than 10%. The maximum entrained oil concentration forecast for any receptor is predicted as 9.2 ppm at the Montebello State Marine Park.

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Consequence Assessment
<u>Dissolved Hydrocarbons</u> Quantitative hydrocarbon spill modelling results for dissolved hydrocarbons are shown in Table 6-27. Dissolved hydrocarbons at concentrations equal to or above the 400 ppb threshold are predicted to extent up to 575 km from the release site. Contact by dissolved hydrocarbons at concentrations equal to or above the 400 ppb threshold is predicted to be greatest at Montebello AMP (15%), as well as at several other sensitive receptors with probabilities less than 10%. The maximum dissolved hydrocarbon concentration forecast for any receptor is predicted as 14.4 ppm at the Montebello AMP. <u>Accumulated Hydrocarbons</u> Quantitative hydrocarbon spill modelling results for accumulated hydrocarbons are shown in Table 6-27. The Montebello Islands, Muiron Islands Marine Management Area – World Heritage Area, Pilbara Islands – Southern Island Group, and Muiron Islands shoreline receptors are predicted to experience shoreline accumulation in excess of the 100 g/m^2 threshold with a probability of 4%. Potential for accumulation of hydrocarbons on shorelines is predicted to be greatest at the Montebello Islands. ***Consequence Assessment Summary*** Modelling of the credible worst-case hydrocarbon spill scenario that may arise from MEE-05 indicates that the spill may impact upon a number of environmental receptors (Table 6-27). The biological consequences of such a spill on identified open water sensitive receptors relate to the potential for catastrophic, long-term impacts to environmental receptors within the spill affected area. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3). The credible worst-case hydrocarbon volumes that can credibly be released by MEE-05 are considerably smaller than the credible worst-case loss of well containment volumes considered in MEE-01 (Section 6.8.3). Additionally, the credible release durations are significantly shorter. These considerations are reflected in the significantly smaller EMBA presented in Table 6-27.

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Table 6-27: Key receptor locations and sensitivities potentially contacted above impact thresholds by the cargo tank loss of containment scenario with summary hydrocarbon spill contact (table cell values correspond to probability of contact [%])

Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																												Probability of hydrocarbon contact and fate (%) (Cossack (Okha) light crude)			
		Physical		Biological																						Socioeconomic and Cultural							
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities / Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (foraging areas, internesting areas and significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Seabirds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas / Heritage – European and Indigenous / Underwater Cultural Heritage	Offshore Oil and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥100 ppb)	Dissolved aromatic hydrocarbon (≥100 ppb)	Accumulated hydrocarbons (>100 g/m²)
Offshore[25]	Montebello AMP	✓	✓	✓			✓	✓							✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		1	18	15	N/A
	Ningaloo AMP	✓	✓					✓		✓					✓	✓			✓		✓	✓	✓	✓	✓	✓		✓	✓		-	2	-	N/A
	Gascoyne AMP	✓	✓												✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	-	4	2	N/A
	Argo-Rowley Terrace AMP	✓	✓					✓							✓	✓			✓			✓	✓	✓		✓			✓		-	-	-	N/A
Submerged Shoals and Banks	Rankin Bank	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	4	N/A
	Glomar Shoal	✓	✓	✓			✓	✓		✓						✓				✓		✓		✓	✓	✓		✓			-	-	6	N/A
Islands	Montebello Islands (including State Marine Park)	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		1	8	4	4
	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	✓	✓	✓	✓		✓	✓				✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	-	4	2	3
	Pilbara Islands – Southern Island Group (Serrurier, Thevenard and Bessieres Islands – State Nature Reserves)	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	4	2	4

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

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Environmental setting	Location / name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions (Woodside's Risk Management Procedure (WM0000PG10055394))																													Probability of hydrocarbon contact and fate (%) (Cossack (Okha) light crude)			
		Physical		Biological																						Socioeconomic and Cultural								
		Water Quality	Sediment Quality	Marine Primary Producers			Other Communities / Habitats								Protected Species									Other Species										
		Open water – (pristine)	Marine Sediment – (pristine)	Coral reef	Seagrass beds / Macroalgae	Mangroves	Spawning/nursery areas	Open water – Productivity/upwelling	Non biogenic reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries / tributaries / creeks / lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (foraging areas, internesting areas and significant nesting beaches)	Sea snakes	Whale sharks	Sharks and rays	Seabirds and/or migratory shorebirds	Pelagic fish populations	Resident /Demersal Fish	Fisheries – commercial	Fisheries – traditional	Tourism and Recreation	Protected Areas / Heritage – European and Indigenous / Underwater Cultural Heritage	Offshore Oil and Gas Infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥100 ppb)	Dissolved aromatic hydrocarbon (≥100 ppb)	Accumulated hydrocarbons (>100 g/m²)
	Pilbara Islands – Middle Island Group	✓	✓		✓		✓		✓			✓		✓		✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	-	-	2
	Muiron Islands (WHA, State Marine Park)	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		-	2	-	4
Mainland (nearshore waters)	Ningaloo Coast (North/North West Cape, Middle and South) (WHA, and State Marine Park)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓		-	1	-	4

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MEE-05 Cargo Tank Loss of Containment – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-05; refer to Figure 6-22, Figure 6-23, Figure 6-24, and Figure 6-25 for bowtie diagrams.

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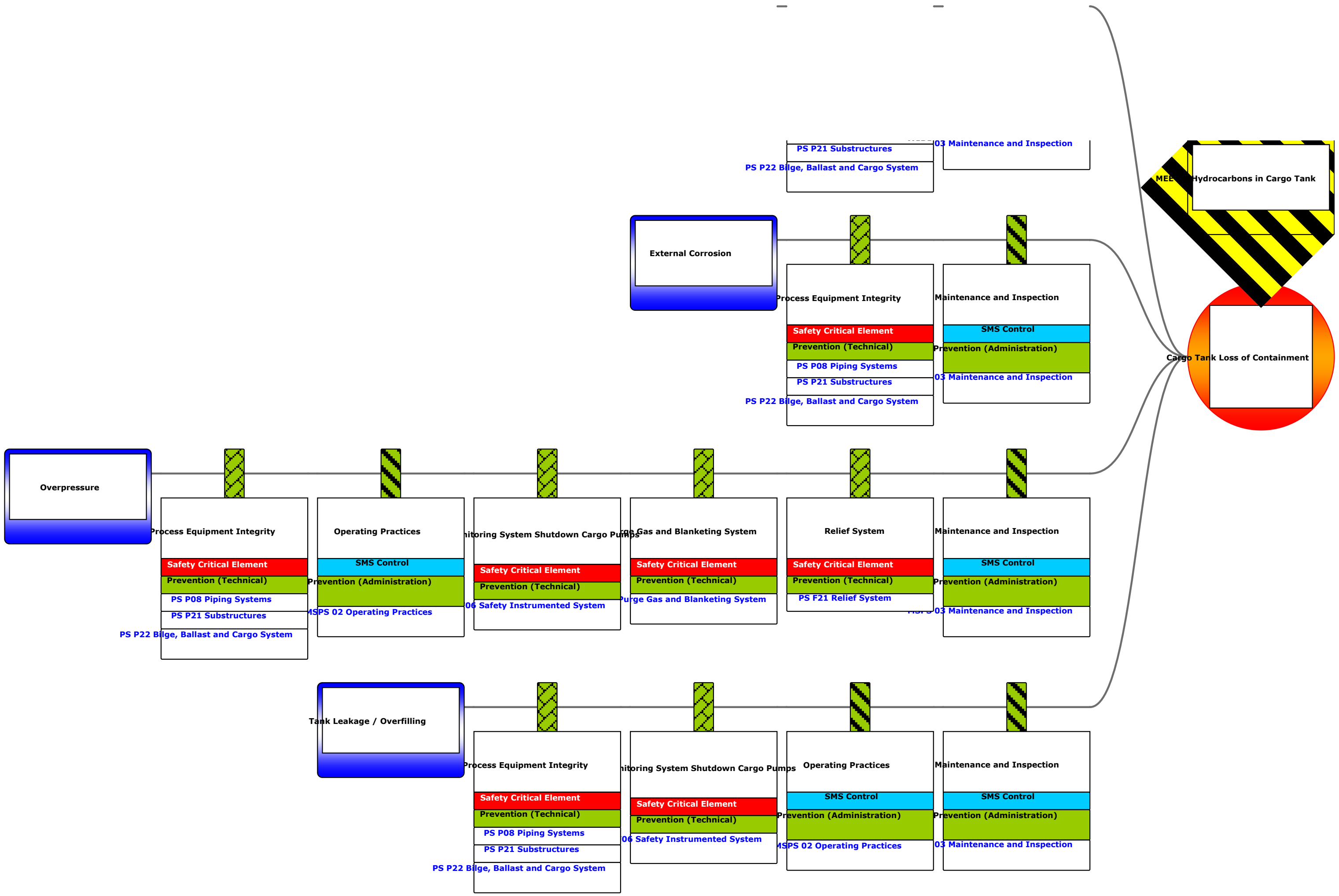

Figure 6-22: MEE-05 Cargo Tank Loss of Containment (Causes 1–4)

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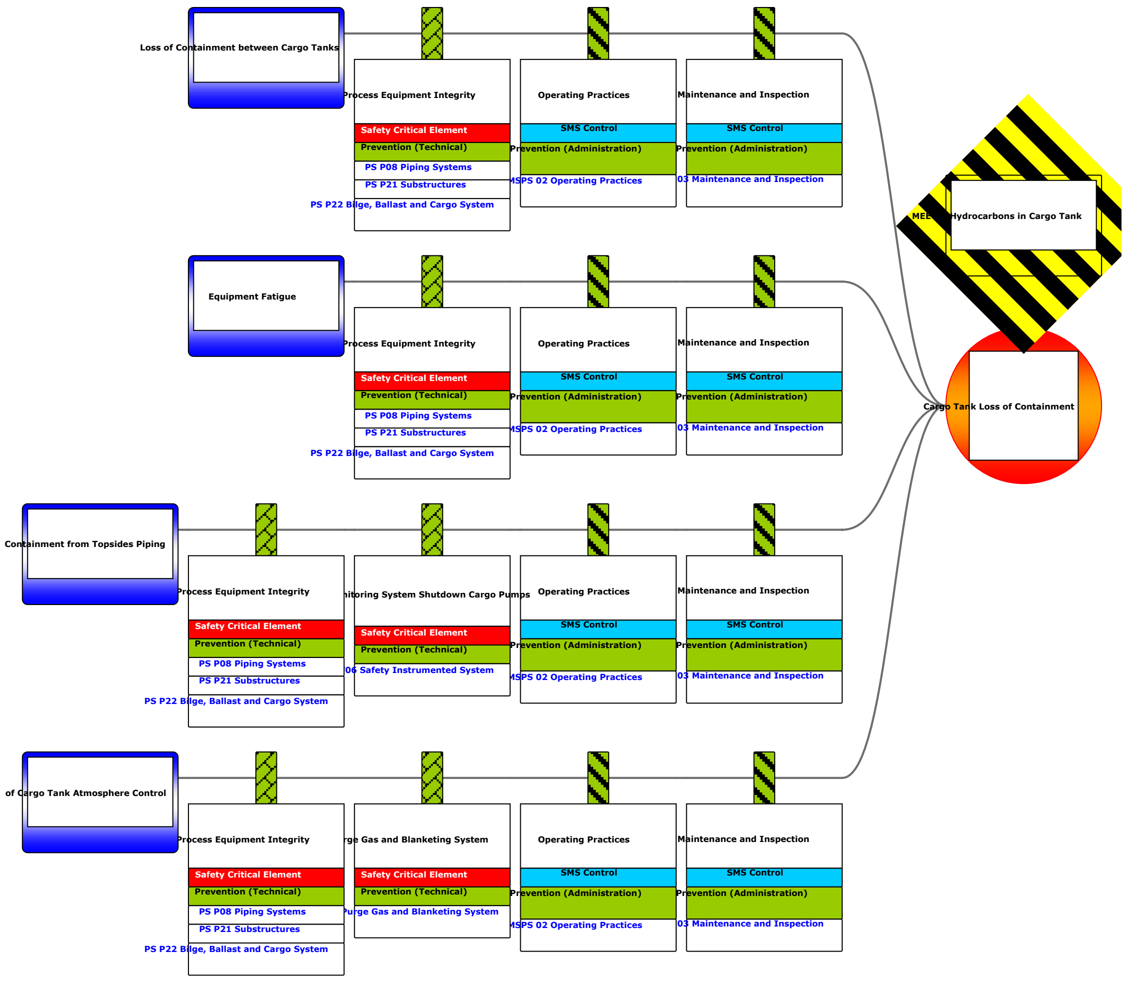

Figure 6-23: MEE-05 Cargo Tank Loss of Containment (Causes 5–8)

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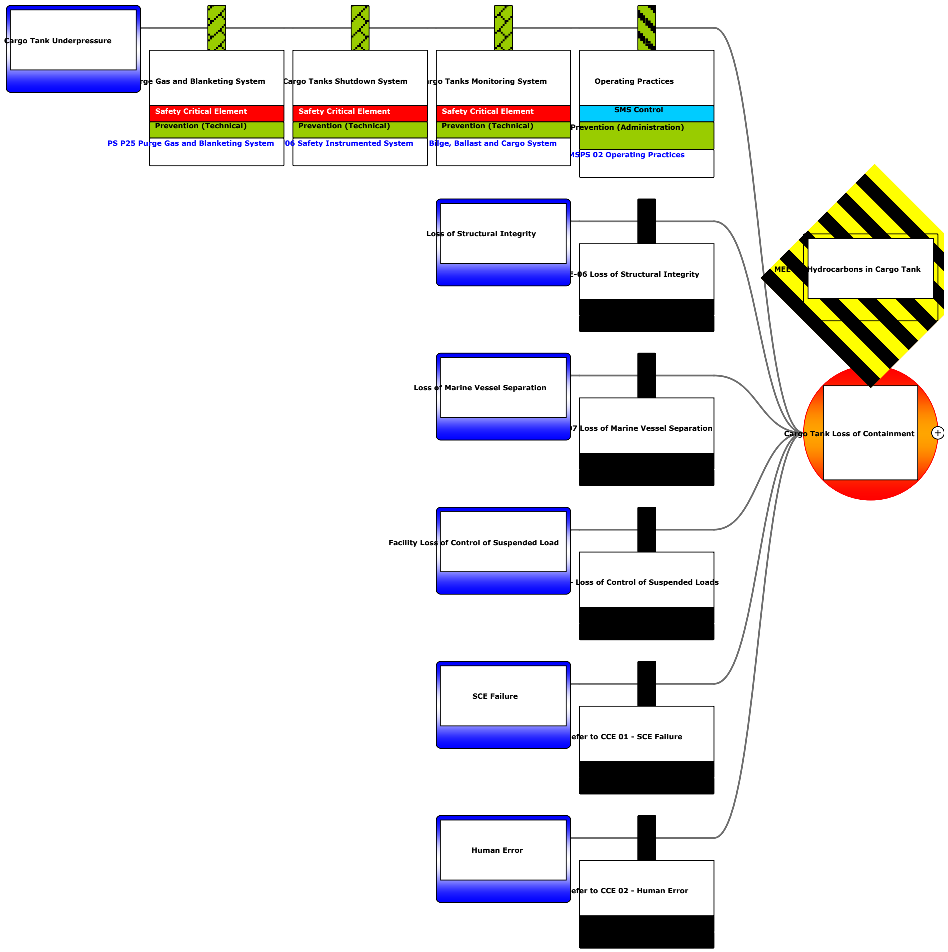

Figure 6-24: MEE-05 Cargo Tank Loss of Containment (Causes 9–14)

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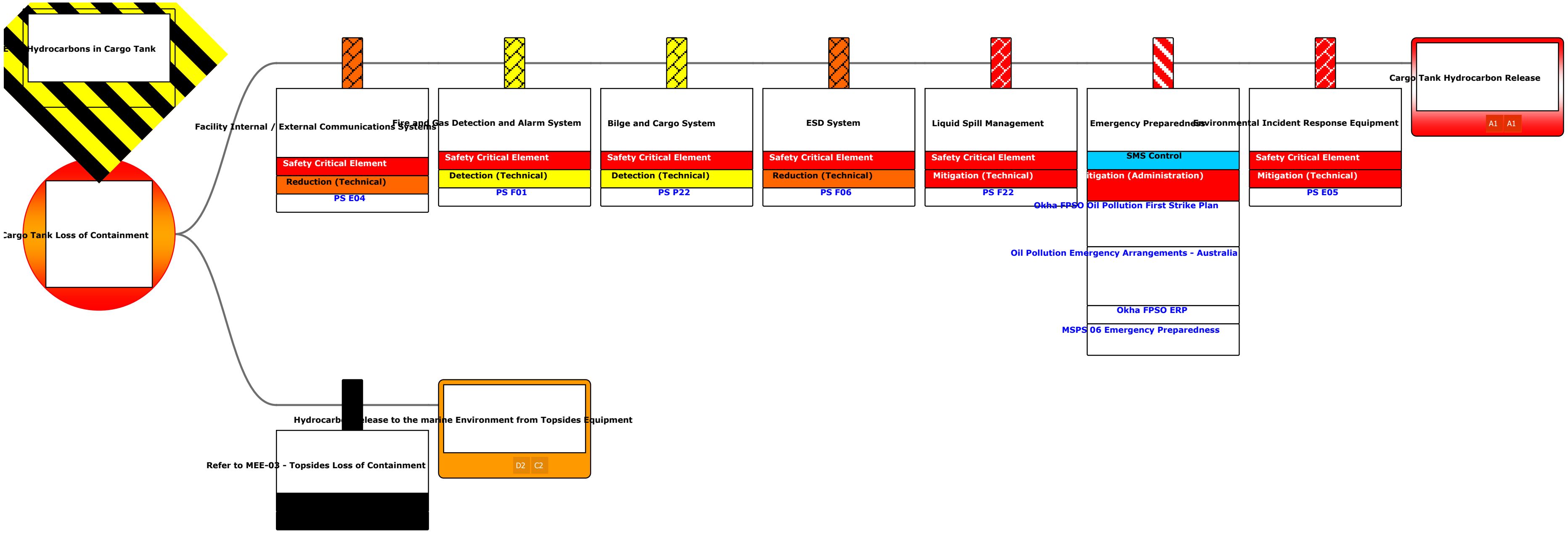

Figure 6-25: MEE-05 Cargo Tank Loss of Containment (Outcomes)

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MEE-05 Cargo Tank Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain cargo system hydrocarbon-containing infrastructure integrity	P08 – Piping Systems P21 – Substructures P22 – Bilge, Ballast and Cargo Systems P25 – Purge Gas and Blanketing System F06 – Safety Instrumented System F21 – Relief Systems	Prevention (Technical)	Yes **C 16.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate prevention and response to accidents and emergencies.	E04 – Safety Critical Communications	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain Fire and Gas detection and Alarm Systems to facilitate prevention and response to fire or gas hazards.	F01 – Fire and Gas Detection and Alarm System	Detection (Technical)	Yes **C 13.2**
Engineering Controls	Maintain bilge detection and alarm systems to mitigate a MEE.	P22 – Bilge, Ballast and Cargo Systems	Detection (Control)	Yes **C 15.3**
Engineering Controls	Maintain Safety Instrumented System (Safety Instrumented Functions and emergency shutdown actions) to detect and respond to predefined initiating conditions and/or initiate responses that put the process plant and equipment in a safe condition (e.g. through appropriate isolation of hazardous inventories) so as to prevent or mitigate the effects of a MEE.	F06 – Safety Instrumented System	Reduction / Control (Technical)	Yes **C 15.2**
Engineering Controls	Maintain open hazardous drains to remove and control environmentally hazardous liquid discharges to prevent or mitigate a MEE.	F22 – Open Hazardous Drains	Mitigation (Technical)	Yes **C 15.3**

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MEE-05 Cargo Tank Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha FPSO to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory	Yes **C 8.5**

MEE-05 Cargo Tank Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
			reporting requirements.	
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • M02 Operating Practices • M03 Maintenance and Inspections.	MSPS-02 Operating Practices MSPS-03 Maintenance and Inspections	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and contingency planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	MSPS 06 – Emergency Preparedness Okha Emergency Response Plan Okha Oil Pollution First Strike Plan (Appendix H) Oil Pollution Emergency Arrangements – Australia	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.
Risk Based Analysis				
For risks identified as MEEs, a more detailed risk based Bowtie Analysis (as outlined in Section 2.7.3) has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event. Application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes: • ongoing hazard identification, risk assessment and the identification of control measures • ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability. For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity. Bowtie analysis was undertaken to assess MEE-05; refer to Figure 6-22, Figure 6-23, Figure 6-24 and Figure 6-25 for bowtie diagrams. A quantitative spill risk assessment was undertaken (refer to Section 6.8.1).				
Company Values				
Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).				
Societal Values				
Refer to Societal Values in demonstration of ALARP for MEE-01 (Section 6.8.3).				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Highly Unlikely unplanned hydrocarbon release as a result of an Okha FPSO cargo tank loss of containment.				

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MEE-05 Cargo Tank Loss of Containment – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of the Okha FPSO and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation. The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures. The application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes: • ongoing hazard identification, risk assessment and the identification of control measures • ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability. Given the controls in place to prevent and control loss of containment events and mitigate their consequences, it is considered that MEE risk associated with Okha FPSO cargo tank loss of containment is managed to ALARP.				

Demonstration of Acceptability
A cargo tank loss of containment has been evaluated as having a ‘High’ risk rating. As per Section 2.8.2, Woodside considers ‘High’ risk ratings as acceptable if managed to ALARP. Due to the consequence associated with MEE-05, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained. Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 16 Cargo tank loss of containment risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 16.1** Maintain cargo system hydrocarbon-containing infrastructure integrity.	Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P08 – Piping Systems to: – provide minimum required mechanical integrity for identified Safety and Environment Critical Piping so as to prevent a loss of containment that may result in an MEE (for operation within defined integrity limits). • P21 – Substructures to: – provide and maintain structural integrity to support SCE systems under all design	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		conditions through service life – prevent structural failure from contributing to the escalation of an MEE by providing support/protection of SCE systems during an emergency event, and/or support containment of environmentally hazardous materials • P22 – Bilge, Ballast and Cargo Systems to: – maintain hull stress and vessel stability within integrity limits. • P25 – Purge Gas and Blanketing System to: – safely prevent the creation of an explosive atmosphere by either preventing oxygen ingress or dilution of hydrocarbon stream. • F06 – Safety Instrumented System to: – detect and respond to pre-defined initiating conditions to protect mechanical integrity. • F21 – Relief Systems to: – protect pressurised equipment, equipment exposed to high pressures and piping from a loss of containment to prevent escalation to an MEE.	
	Refer to **C 12.2**	Refer to **PS 12.2**	Refer to **MC 12.1**
	Refer to **C 13.2**	Refer to **PS 13.2**	Refer to **MC 12.1**
	C 16.2 Maintain bilge detection and alarm systems to mitigate a MEE.	**PS 16.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P22 – Bilge, Ballast and Cargo Systems: – to maintain hull stress and vessel stability within integrity limits.	Refer to **MC 12.1**
	Refer to **C 15.2**	Refer to **C 15.2**	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	C 16.3 Maintain open hazardous drains to remove and control environmentally hazardous liquid discharges to prevent or mitigate a MEE.	**PS 16.3** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F22 – Open Hazardous Drains to: – prevent escalation of an incident following loss of containment, fire and/or explosion by removing or containing flammable liquid from hazardous areas – support appropriate containment and disposal of environmentally hazardous liquids to avoid damage to the environment.	Refer to **MC 12.1**
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.8 Unplanned Hydrocarbon Release: Loss of Structural Integrity (MEE-06)

Context		
Wells and Reservoirs – Section 3.5.2 Subsea Infrastructure – Section 3.5.3 Topsides – Section 3.5.1 Process Description – Section 3.6.2	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release caused by a loss of structural integrity, leading to: • MEE-02 – subsea equipment loss of containment • MEE-03 – Topsides loss of containment • MEE-04 – Offtake equipment loss of containment • MEE-05 – FPSO Cargo tank loss of containment.	-	X	X	X	X	X	X	B	A	1	H	LCS GP PJ RBA CV SV	Acceptable if ALARP	EPO 17

Description of Source of Risk

Background

The Okha FPSO contains hydrocarbons in a range of infrastructure, including cargo tanks, process inventory, non-process inventory, flowlines and risers.

Woodside has identified the potential for hydrocarbon release due to the extreme environmental conditions or other causes which result in an exceedance of the design criteria and a catastrophic failure of the facility and individual equipment (e.g. cranes, flare, etc.) which could cause damage to adjacent equipment, leading to hydrocarbon releases to the environment.

Extreme environmental conditions (cyclone) could result in loss of structural integrity of the Okha FPSO resulting in significant oil spill to the environment (from risers, cargo tanks and/or topsides equipment). There is also the possibility of Okha FPSO capsizing or foundering caused by strong winds and extreme waves. This may induce pipework fatigue and loose/dislodged objects/projectiles causing impact to equipment/pipework resulting in loss of containment. Structural failures could be localised, or could, in more extreme situations, result in loss of containment from multiple storage locations on the Okha FPSO.

Extreme environmental conditions may also result in movement of the vessel and result in releases from lowlines/risers (MEE-02) or topsides equipment or storage (MEE-02–MEE-05). The worst-case environmental consequence ranking is an ‘A’ for these events related to Loss of Structural Integrity. The release of hydrocarbons as a result of loss of structural integrity is considered a Major Environment Event (MEE-06). The hazard associated with this MEE is hydrocarbons in the Okha facility.

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Context

The following causes of structural failure of the Okha facility were identified:

- internal and external corrosion
- equipment fatigue
- extreme weather (cyclone, high waves)
- mooring system failure
- vessel stresses through loading and stability
- fire or explosion escalation to structure (including events captured in MEE-02, MEE-03, MEE-04 and MEE-05).

A number of common failure causes due to human error and Safety Critical Equipment (SCE) failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

Loss of Structural Integrity – Credible Hydrocarbon Spill Scenario

A loss of structural integrity could result in a significant release of hydrocarbons. A loss of structural integrity may result in credible spill scenarios consistent with a loss of well containment (MEE-01, Section 6.8.3), subsea equipment loss of containment (MEE-02, Section 6.8.4), topsides loss of containment (MEE-03, Section 6.8.5) and Okha FPSO cargo tank loss of containment (MEE-05, Section 6.8.7). The worst-case credible spill scenarios associated with these MEEs are discussed in the relevant sections above; refer to these sections for further information.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in structural design and construction. The Okha facility has never experienced a worst-case loss of containment due to structural failure in its operational history.

Decision Type

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk-based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

The loss of structural integrity is considered a Major Environment Event (MEE-06). The hazard associated with this MEE is hydrocarbons contained within the Okha FPSO and associated infrastructure.

Quantitative Spill Risk Assessment

Credible worst-case stochastic spill modelling for the scenarios associated with MEE-01 (Section 6.8.3), MEE-02 (MEE-02, Section 6.8.4), MEE-03 (MEE-03, Section 6.8.5) and MEE-05 (Section 6.8.7) has been undertaken. Results of these modelling studies have been used to inform the consequence assessment for these MEEs; these assessments are applicable to the consequence assessment for a loss of structural integrity event.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a loss of structural integrity. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as Highly Unlikely (1).

Consequence Assessment

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

- Loss of Well Containment, Section 6.8.3 (MEE-01)
- Subsea Equipment Loss of Containment, Section 6.8.4 (MEE-02)
- Topsides Loss of Containment, Section 6.8.5 (MEE-03)
- Offtake Equipment Loss of Containment, Section 6.8.6 (MEE-04)
- Cargo Tank Loss of Containment, Section 6.8.7 (MEE-05).

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

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MEE-06 Loss of Structural Integrity – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-06; refer to Figure 6-26, Figure 6-27, and Figure 6-28 for bowtie diagrams.

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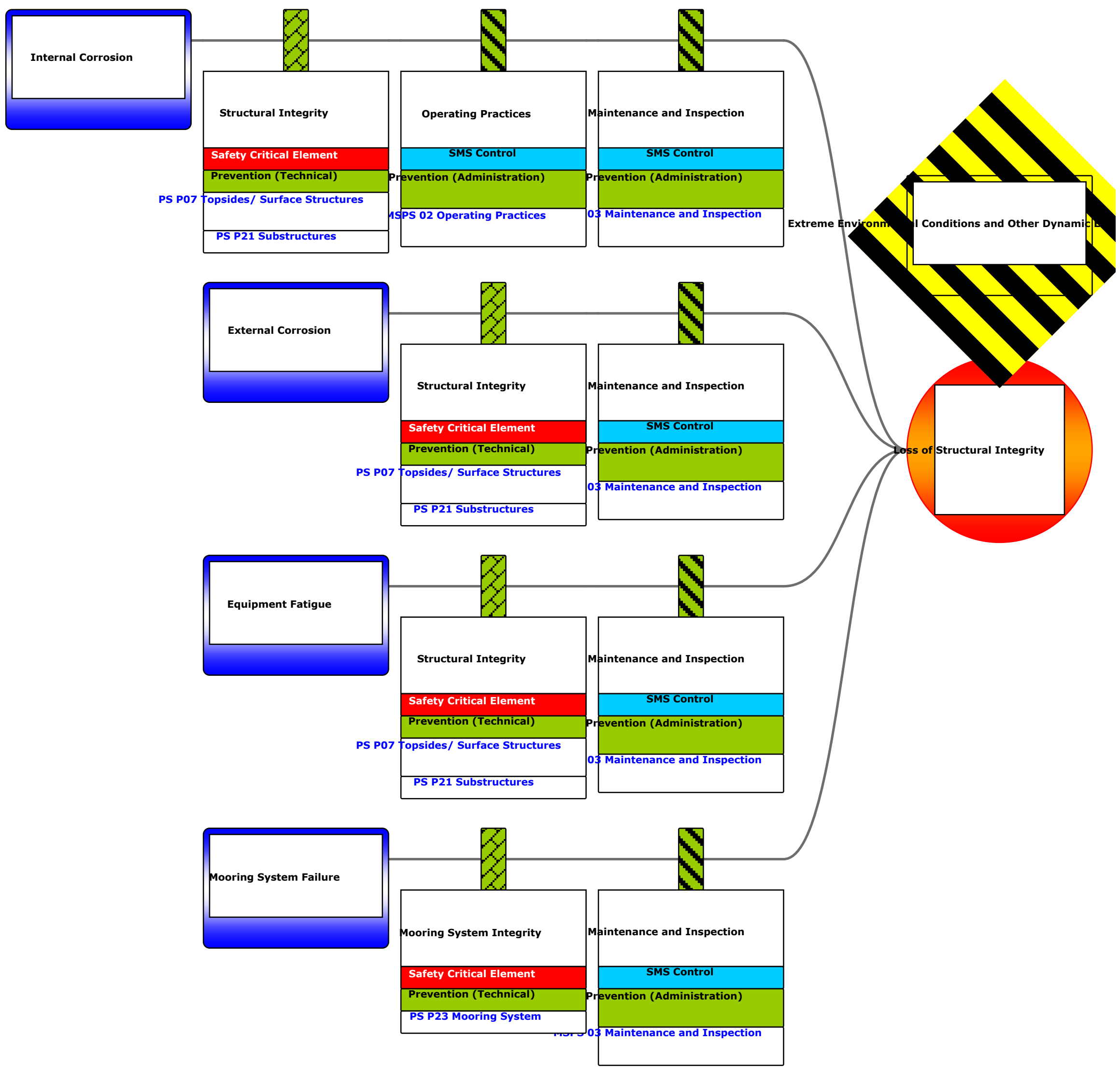

Figure 6-26: MEE-06 Loss of Structural Integrity (Causes 1–4)

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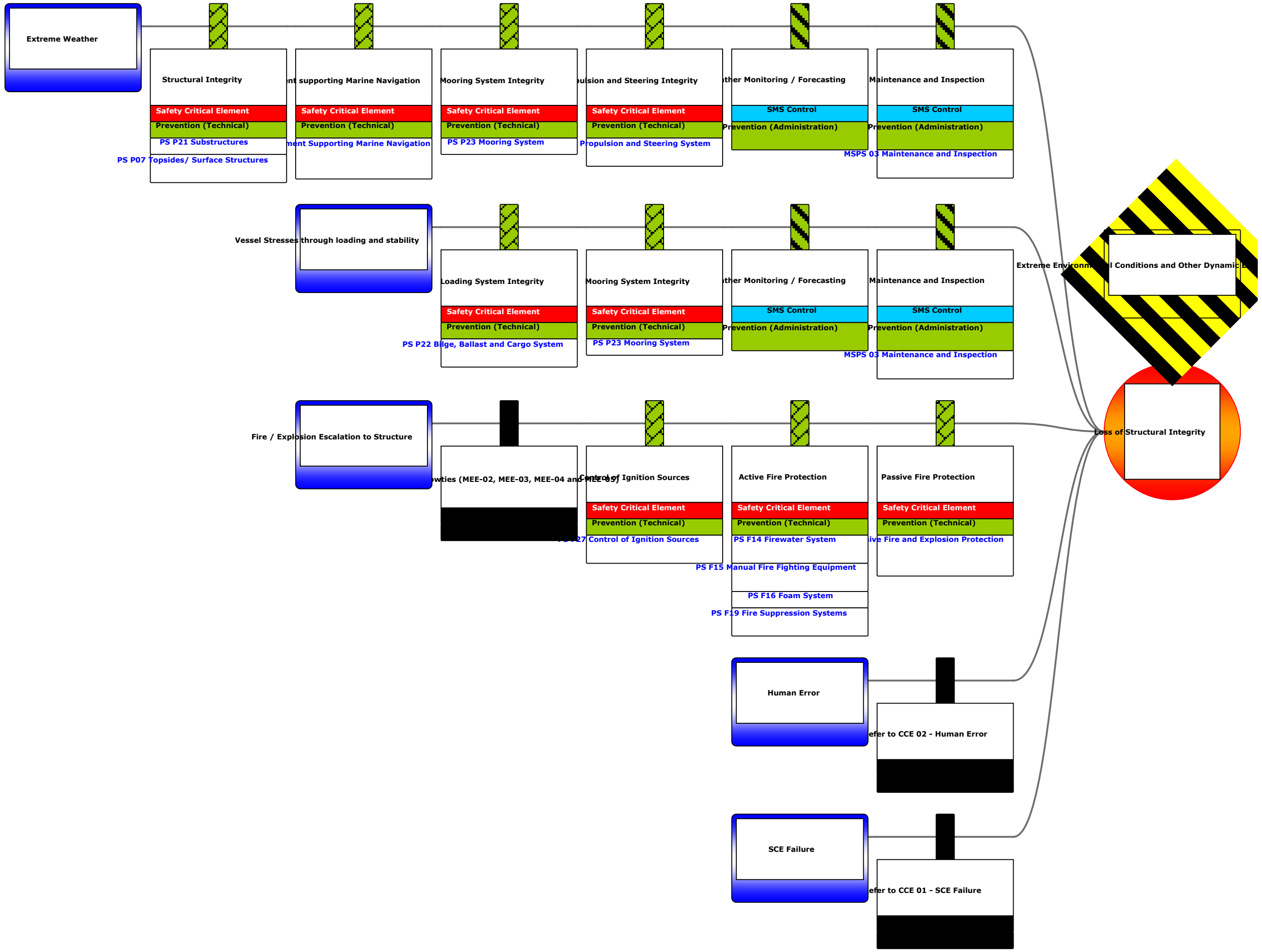

Figure 6-27: MEE-06 Loss of Structural Integrity (Causes 5–9)

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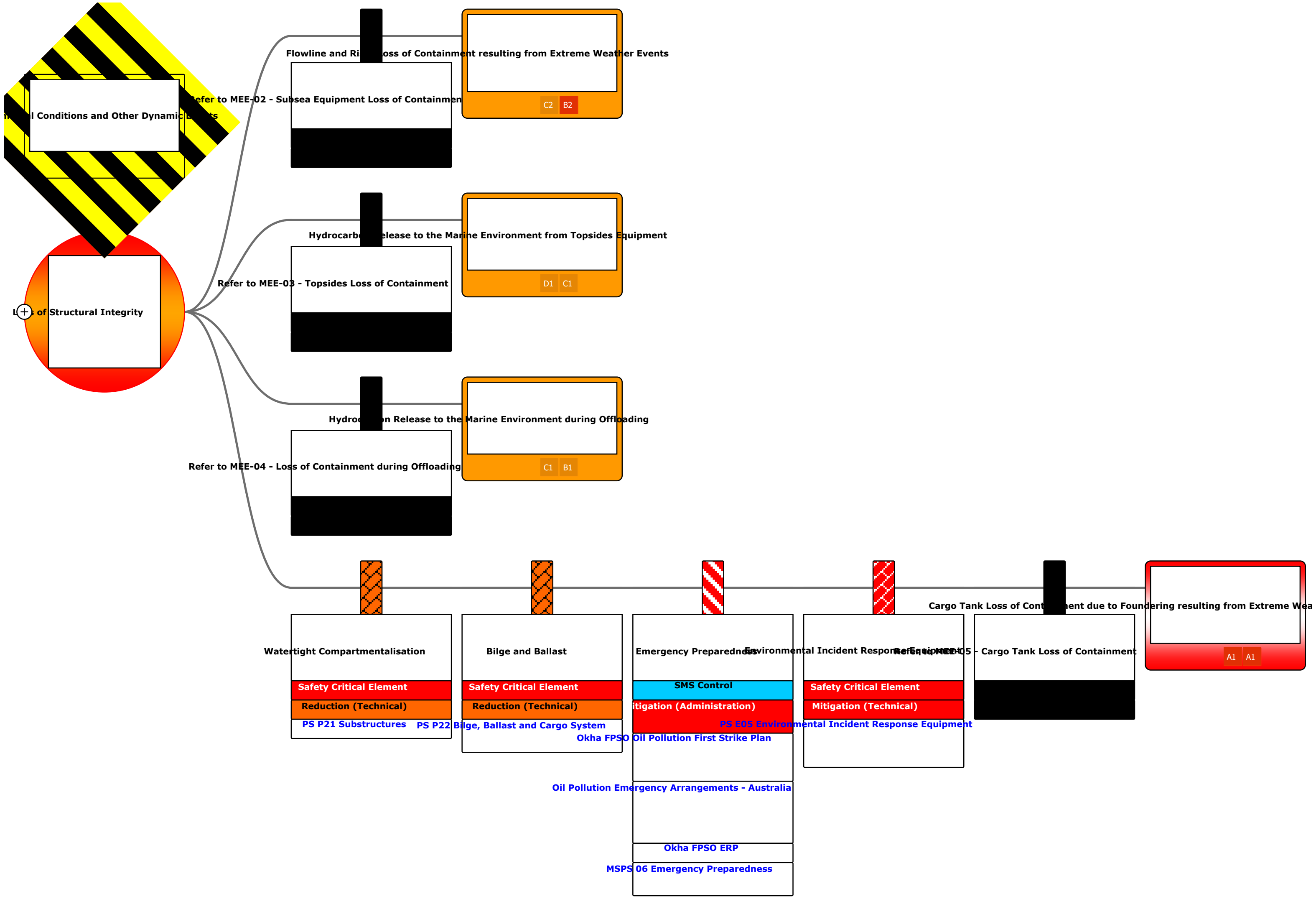

Figure 6-28: MEE-06 Loss of Structural Integrity (Outcomes)

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MEE-06 Loss of Structural Integrity – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain structural integrity to ensure availability of critical systems during a major accident or environment event and prevent structural failures from contributing to escalation of a MEE.	P07 – Topsides Surface Structure P21 – Substructures P22 – Bilge, Ballast and Cargo Systems P23 – Mooring Systems P24 – Propulsion and Steering Systems P33 – Equipment Supporting Marine Navigation	Prevention (Technical)	Yes **C 17.1**
Engineering Controls	Maintain control of ignition sources and fire protection to prevent loss of structural integrity.	F14 – Firewater System F15 – Manual Fire Fighting Equipment F16 – Foam Systems F17 – Fire Water Pump F18 – Fire Main F19 – Fire Suppression Systems F20 – Passive Fire and Explosion Protection F27 – Control of Ignition Sources	Prevention (Technical)	Yes **C 17.2**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain availability of critical external and internal communication systems to facilitate response to accidents and emergencies	E04 – Safety Critical Communications	Mitigation (Technical)	Yes **C 12.2**
Engineering Controls	Maintain vessel stability and structural integrity to prevent structural failures from contributing to escalation of a MEE.	P21 – Substructures P22 – Bilge, Ballast and Cargo Systems	Reduction (Technical)	Yes **C 17.3**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				

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MEE-06 Loss of Structural Integrity – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha facility to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP. Thus, contributing to management of associated potential environmental consequences of MAEs.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • M02 Operating Practices • M03 Maintenance and Inspections.	MSPS-02 Operating Practices MSPS-03 Maintenance and Inspections	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and contingency planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan	MSPS 06 Okha Emergency Response Plan Okha Oil Pollution First Strike Plan (Appendix H)	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the

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MEE-06 Loss of Structural Integrity – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	• Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	Oil Pollution Emergency Arrangements – Australia		ALARP assessment of controls related to hydrocarbon spill response.

Risk Based Analysis

For risks identified as MEEs, a more detailed risk based Bowtie Analysis (as outlined in Section 2.7.3) has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-06; refer to Figure 6-26, Figure 6-27 and Figure 6-28 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer Section 6.8.1).

Company Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

Societal Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Remote likelihood unplanned hydrocarbon release as a result of a loss of structural integrity.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of Okha FPSO and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha FPSO Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures and implementation of the Okha FPSO Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, it is considered that MEE risk associated with Loss of Structural Integrity is managed to ALARP.

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Demonstration of Acceptability
Loss of structural integrity has been evaluated as having a 'High' level of risk rating (via the consideration of applicable MEEs). As per Section 2.8.2, Woodside considers 'High' risk ratings as acceptable if managed to ALARP. Due to the consequence associated with MEE-06, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained. Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 17 Structural integrity loss of containment risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program	**C 17.1** Maintain structural integrity to ensure availability of critical systems during a major accident or environment event and prevent structural failures from contributing to escalation of a MEE.	**PS 17.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P07 – Substructures and P21 – Topsides Surface Structure to both: – provide and maintain structural integrity to support SCE systems under all design conditions through service life – prevent structural failure from contributing to the escalation of a MEE by providing support/protection of SCE systems during an emergency event, and/or support containment of environmentally hazardous material. • P22 – Bilge, Ballast and Cargo Systems to: – maintain hull stress and vessel stability within integrity limits. • P23 – Mooring Systems to: – provide station, keeping within allowable excursion envelope – provide ability to disconnect facility from mooring on demand; and – provide ability to disconnect offtake tanker from facility on demand.	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		• P24 – Propulsion and Steering Systems and P33 – Equipment Supporting Marine Navigation to together (within Operational Area): – manoeuvre the facility under self-propulsion away from hazardous conditions – provide critical information to enable safe navigation of the FPSO; to allow the FPSO to disconnect and avoid adverse environmental conditions exceeding structural integrity limits.	
	C 17.2 Maintain control of ignition sources and fire protection to prevent loss of structural integrity.	**PS 17.2** Integrity will be managed in accordance with SCE management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F14 – Firewater System • F15 – Manual Fire Fighting Equipment • F16 – Foam Systems • F17 – Fire Water Pump • F18 – Fire Main • F19 – Fire Suppression Systems; to together: – provide reliable and secure delivery of firefighting medium (e.g. firewater, gaseous suppressant, foam) at the required flows, pressures, coverage and discharge rates to reduce the likelihood of escalation – where safe to do so, enable facility emergency response personnel to apply fire fighting medium to support fire control and limit escalation. • F20 – Passive Fire and Explosion Protection to: – mitigate the effects of a fire or explosion by maintaining the integrity	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		of critical structure and equipment and limiting the potential for escalation. • F27 – Control of Ignition Sources to: – prevent ignition of flammable or explosive atmospheres within identified Hazardous Areas.	
	Refer to **C 12.2**	Refer to **PS 12.2**	Refer to **MC 12.1**
	C 17.3 Maintain vessel stability and structural integrity to prevent structural failures from contributing to escalation of a MEE.	**PS 17.3** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P21 – Substructures: – to prevent structural failure from contributing to the escalation of an MEE by providing support/protection of SCE systems during an emergency event, and/or support containment of environmentally hazardous material. • P22 – Bilge, Ballast and Cargo Systems: – to maintain hull stress and vessel stability within integrity limits.	Refer to **MC 12.1**
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.9 Unplanned Hydrocarbon Release: Loss of Marine Vessel Separation (MEE-07)

Context		
Subsea Infrastructure – Section 3.5.3 Riser Turret Mooring System – Section 3.5.5 Vessels – Section 3.7 Subsea Inspection, Maintenance and Repair Activities – Section 3.10	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release caused by a loss of marine vessel separation, leading to: • MEE-02 – Subsea flowline and riser loss of containment • MEE-03 – Topsides loss of containment • MEE-04 – Offtake equipment loss of containment • MEE-05 – Okha FPSO Cargo tank loss of containment.	-	X	X	X	X	X	X	B	A	1	H	LC S GP PJ RB A CV SV	Acceptable if ALARP	EPO 18

Description of Source of Risk

Background

A loss of marine vessel separation between a vessel and the Okha FPSO may result in a loss of hydrocarbon containment from the Okha facility and/or the release of fuel from the vessel. A vessel collision with the Okha FPSO has been identified as a potential MEE (MEE-07). Vessel collisions can arise from:

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

The different collision hazards involve significantly different sized vessels and collision speeds, hence, differing impact energies and consequences, and have been assessed.

Visiting Vessels

Visiting vessels are defined as those which are routinely used to service, or offtake cargo from, the Okha FPSO. Operating procedures will dictate how vessels are operated, loaded and unloaded, but it will generally occur so that the prevailing winds move the vessel away from the facility. The primary causes of visiting vessel collisions are failure to follow safe procedures and communication errors between the marine vessels and Okha operations. These errors could be worsened by vessel station keeping failures or operations in adverse weather conditions.

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A number of common failure causes due to human error and Safety Critical Equipment (SCE) failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

Errant Passing Vessels

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

The causes of errant passing vessel collisions include:

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

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

Loss of Vessel Separation – Credible Hydrocarbon Spill Scenario

A loss of marine vessel separation could result in a significant release of hydrocarbons. Hydrocarbon releases will result in a spill to the marine environment as described in Section 6.8.4 (MEE-02 – subsea flowline and riser loss of containment), Section 6.8.5 (MEE-03 – Topsides loss of containment), Section 6.8.6 (MEE-04 – Offtake equipment loss of containment) and Section 6.8.7 (MEE-05 – FPSO cargo tank loss of containment). Worst-case hydrocarbon release scenarios that could result from loss of marine vessel separation are discussed in the relevant sections referenced above. Relevant trajectory modelling, as applicable to these scenarios, is also discussed in the relevant sections. In addition, vessel cargo, including diesel inventory, could be spilled if the cause of the loss of facility integrity was a collision from a support vessel.

A loss of vessel separation may lead to the accidental release of diesel from the fuel tanks on the vessel(s) involved. For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmental receptor, several factors must align as follows:

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

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

A collision between the Okha FPSO or subsea support vessel with a third-party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels) was considered the only credible event that could release a significant quantity of diesel to the environment. This was assessed as being credible but Highly Unlikely given:

- the facility support vessels typically operate close to the Okha FPSO (an area avoided by commercial shipping and fishing)
- the presence of subsea vessels in the Operational Area is typically temporary (e.g. while undertaking IMMR activities)
- vessels undertaking the Petroleum Activities Program typically operate of low speeds or are stationary
- the standard vessel operations and equipment in place to prevent collision at sea, and the construction and placement of storage tanks.

In the unlikely event of a collision between the Okha FPSO or subsea support vessel with a third-party vessel, the maximum volume likely to be released from rupture of a vessel diesel fuel tank has been estimated to be 105 m^3. This is based on the wing tank of support vessels holding ~100 m^3 to 120 m^3 diesel, the fuel tank is full, and a conservative assumption that that 80% of the diesel fuel would spill to the marine environment. Release characteristics for a vessel diesel fuel tank loss of containment scenario are summarised in Table 6-26.

Table 6-28: Summary of the worst-case vessel diesel fuel tank loss of containment release scenario

Scenario	Hydrocarbon	Duration (hours)	Depth (m)	Latitude (WGS84)	Longitude (WGS84)	Total Diesel Release Volume (m^3)
Vessel diesel fuel tank loss of containment	Diesel	Instantaneous	Surface	19° 35' 21" S	116° 26' 48" E	105 m^3

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Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO operation. In the company's 60-year history, it has not experienced any loss of vessel separation events that have resulted in significant releases or significant environmental impacts. The Okha facility has never experienced a worst-case hydrocarbon release from a loss of vessel separation in its operational history.

Decision Type

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk-based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling. Company and societal values were also considered in the demonstration of ALARP and acceptability, through peer review, benchmarking and stakeholder consultation.

A loss of marine vessel separation is considered a MEE (MEE-07). The hazard associated with this MEE is the hydrocarbon inventory on the Okha FPSO, subsea flowlines and riser, and fuel onboard vessels.

Quantitative Spill Risk Assessment

Credible worst-case hydrocarbon scenarios for MEE-02, MEE-03, MEE-04 and MEE-05 are considered to apply to a loss of marine vessel separation, as they may credibly arise from damage to the Okha facility and loss of vessel fuel.

Refer to Sections 6.8.4, 6.8.5, 6.8.6, and 6.8.7 for additional information on quantitative spill risk assessments for these scenarios.

Spill modelling of the worst-case credible loss of vessel diesel fuel was undertaken by RPS, on behalf of Woodside, to determine the fate of hydrocarbons released based on the assumptions in Section 6.8.1. Modelling was undertaken over all seasons to address year-round operations. This is considered to provide a conservative estimate of the EMBA and the potential impacts from the identified worst-case credible release volumes for all loss of well containment scenarios.

Consequence

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a loss of vessel separation. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS APASA, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.3) and relevant literature and studies considering the effects of hydrocarbon exposure.

Likelihood

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance, infrastructure marked on marine charts), the likelihood has been taken as Highly Unlikely (1).

Consequence Assessment

Environment that May Be Affected

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

- Subsea Equipment Loss of Containment, Section 6.8.4 (MEE-02)
- Topsides Loss of Containment, Section 6.8.5 (MEE-03)
- Offtake Equipment Loss of Containment, Section 6.8.6 (MEE-04)
- Cargo Tank Loss of Containment, Section 6.8.7 (MEE-05).

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

Potential impacts relating to a vessel diesel fuel tank loss of containment are discussed in the following sections below.

Surface Hydrocarbons

The modelled surface hydrocarbons are forecast to drift down current of the release location with the trajectory dependent on prevailing wind and current conditions at the time. Modelling results indicate no contact with sensitive receptors by surface (floating) hydrocarbons above the impact threshold (10 g/m^2) at probabilities of 1% or greater.

Entrained Hydrocarbons

Modelling results indicate no contact with sensitive receptors by entrained hydrocarbons above impact the threshold (500 ppb) at probabilities of 1% or greater.

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Consequence Assessment
<u>Dissolved Hydrocarbons</u> Modelling results indicate no contact with sensitive receptors by dissolved hydrocarbons above the impact threshold (500 ppb) at probabilities of 1% or greater. <u>Accumulated Hydrocarbons</u> Modelling results indicate no contact with sensitive receptors by accumulated shoreline hydrocarbons above the impact threshold (100 g/m^2) at probabilities or 1% of greater, with a maximum accumulated volume of <1 m^3 along all shoreline receptors. ***Consequence Assessment Summary*** Modelling of the credible worst-case hydrocarbon spill scenario that may arise from MEE-05 (discussed in Section 6.8.7) indicates that the spill may impact upon a number of environmental receptors (Table 6-27). The biological consequences of such a spill on identified open water sensitive receptors relate to the potential for catastrophic, long-term impacts to environmental receptors within the spill affected area. Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3). Potential impacts of a hydrocarbon spill to these receptors are considered in MEE-01 (Section 6.8.3).

MEE-07 Loss of Marine Vessel Separation – Risk Analysis
Bowtie risk analysis was undertaken to assess MEE-07; refer to Figure 6-29 and Figure 6-30 for bowtie diagrams.

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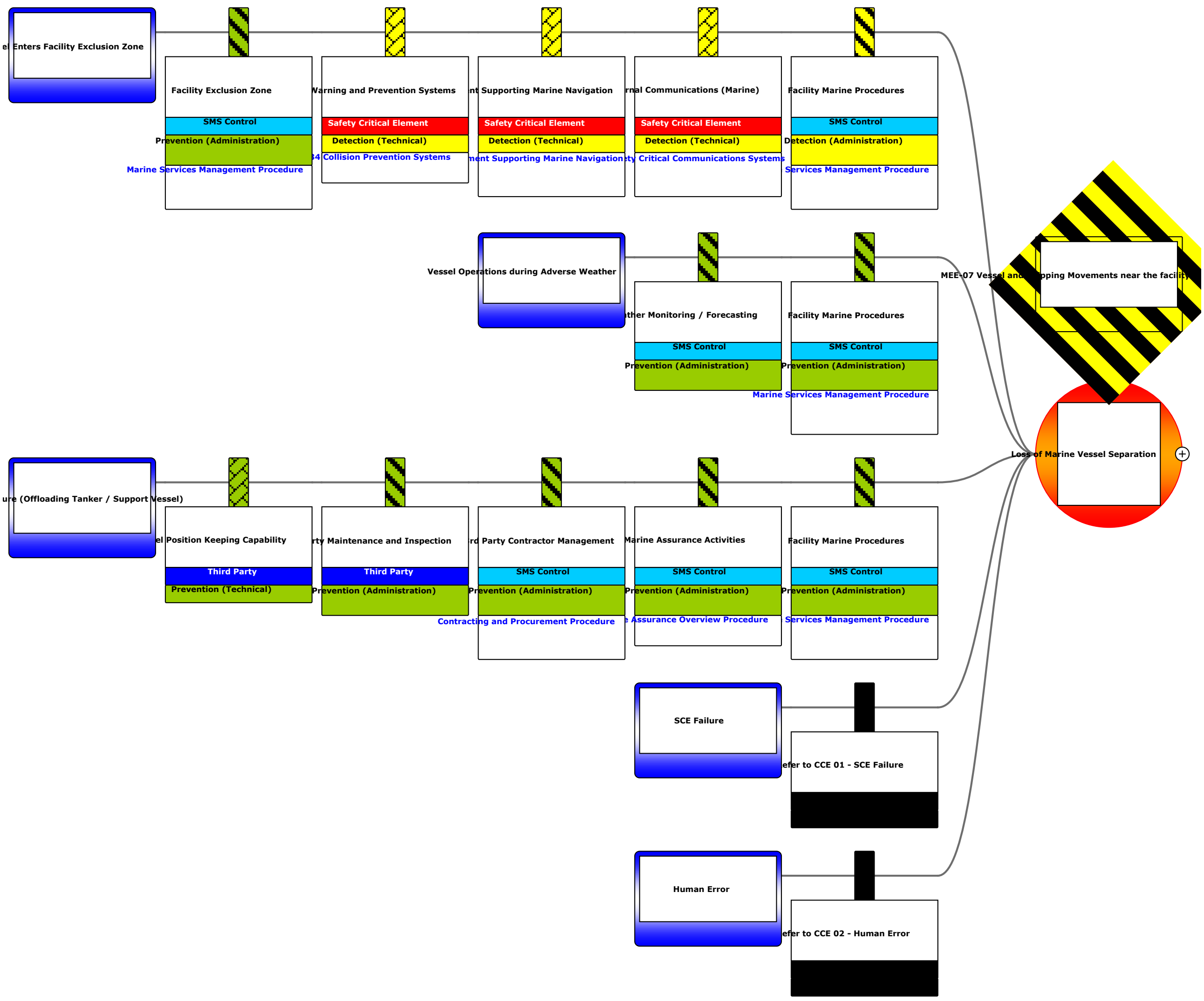

Figure 6-29: MEE-07 Loss of Marine Vessel Separation (Causes 1–5)

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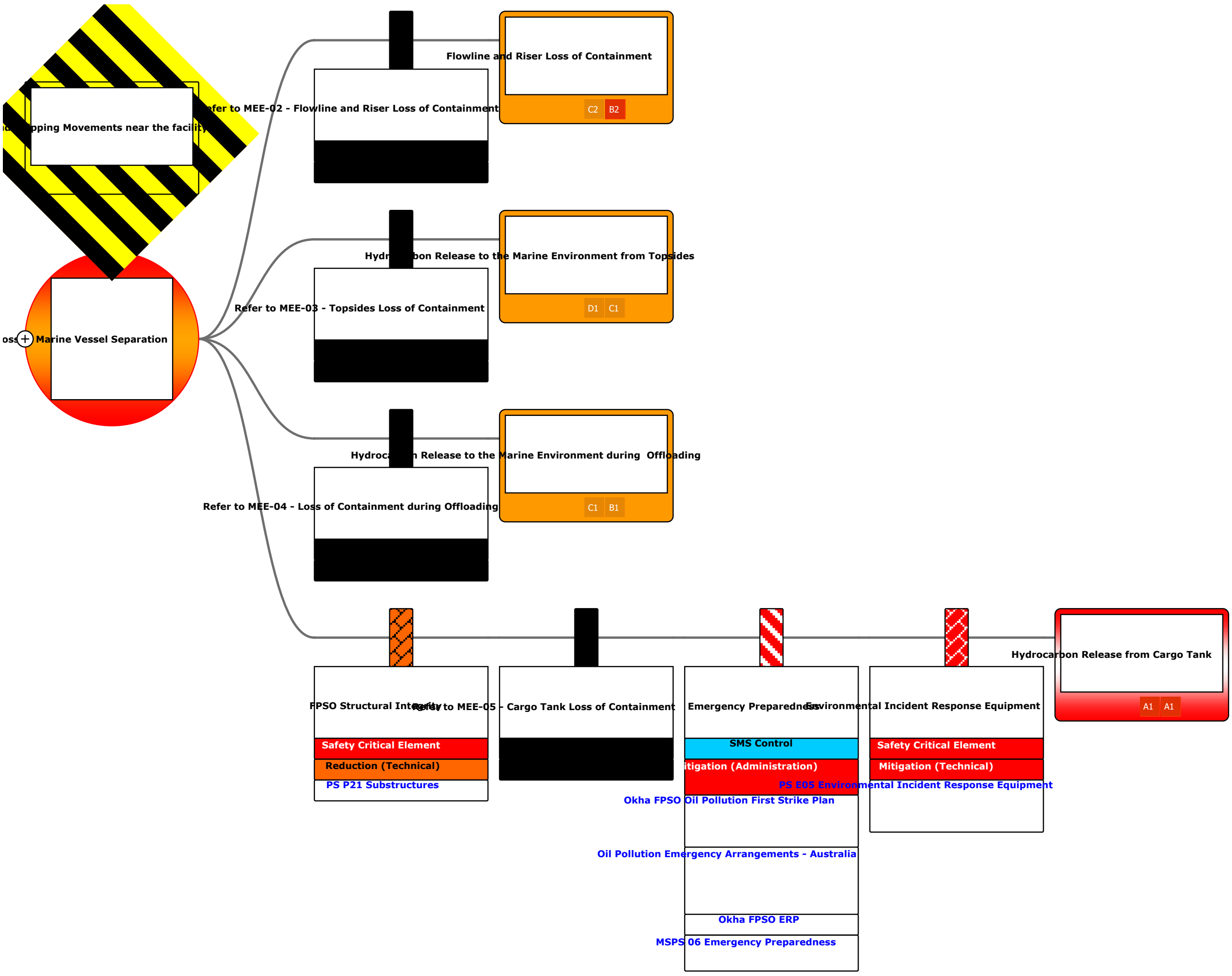

Figure 6-30: MEE-07 Loss of Marine Vessel Separation (Outcomes)

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MEE-07 Loss of Marine Vessel Separation – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain collision warning systems and navigational aids and critical communications systems to alert facility of a potential collision with marine vessels, and to alert marine vessels of facility location so that they may take timely action to avoid the facility and hence reduce likelihood of collision.	P34 – Collision Prevention Systems P33 – Equipment Supporting Marine Navigation E04 – Safety Critical Communications	Detection (Technical)	Yes **C 18.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Engineering Controls	Maintain hull structural integrity to prevent structural failures as a result of ship collision from contributing to escalation of a MEE.	P21 – Substructures	Reduction (Technical)	Yes **C 18.2**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Oil Pollution First Strike Plan (Appendix H).	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha facility to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**

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MEE-07 Loss of Marine Vessel Separation – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	Thus, contributing to management of associated potential environmental consequences of MAEs.			
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • Contracting and Procurement Procedure • Marine Assurance Overview Procedure • Marine Services Management Procedure.	Marine Services Management Procedure Marine Assurance Overview Procedure Contracting and Procurement Procedure	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and contingency planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	MSPS 06 Okha Emergency Response Plan Okha Oil Pollution First Strike Plan (Appendix H) Oil Pollution Emergency Arrangements – Australia	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.
Risk Based Analysis				
For risks identified as MEEs, a more detailed risk based Bowtie Analysis (as outlined in Section 2.7.3, has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following				

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MEE-07 Loss of Marine Vessel Separation – Demonstration of ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***

hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-07; refer to Figure 6-29 and Figure 6-30 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer Section 6.8.1).

Company Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

Societal Values

Refer to Societal Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Remote likelihood unplanned hydrocarbon release as a result of a loss of marine vessel separation.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of the Okha FPSO and ensuring the systems are operated within their design envelope through operating practices and assurance through maintenance and inspection. If hydrocarbon loss of containment occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha Safety Case, SCE management procedures including technical performance standards for Safety Critical Elements (SCEs) and Management System Performance Standards (MSPS) for Safety Critical Procedures.

The application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, alongside procedural control of Okha FPSO operations, it is considered that MEE risk associated with loss of marine vessel separation is managed to ALARP.

Demonstration of Acceptability

Loss of marine vessel separation has been evaluated as having a ‘High’ risk rating (via the consideration of applicable MEEs). As per Section 2.8.2, Woodside considers ‘High’ risk ratings acceptable if managed to ALARP. Due to the consequence associated with MEE-07, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained.

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Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 18 Loss of marine vessel separation risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 18.1** Maintain collision warning systems and navigational aids to alert facility of a potential collision with marine vessels, and to alert marine vessels of facility location so that they may take timely action to avoid the facility and hence reduce likelihood of collision.	**PS 18.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P34 – Collision Prevention Systems to: – alert facility of a potential collision with marine vessels – alert marine vessels of facility location so that they may take timely action to avoid the facility and hence reduce likelihood of collision. • P33 – Equipment Supporting Marine Navigation to: – provide critical information to enable safe navigation of the NY FPSO in disconnected mode to avoid an MEE. • E04 – Safety Critical Communications to: – allow effective ER communications in emergencies, including: o internal communications such as audible and visual warning systems, and voice communications during emergency events o external communications such as voice communications to adjacent facilities, aircraft and vessels, and external incident control centres during emergency events.	Refer to **MC 12.1**
	C 18.2 Maintain hull structural integrity to prevent	**PS 18.2** Integrity will be managed in accordance with SCE	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	structural failures as a result of ship collision from contributing to escalation of a MEE.	Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P21 – Substructures to: – provide and maintain structural integrity to support SCE systems under all design conditions through service life – prevent structural failure from contributing to the escalation of an MEE by providing support/ protection of SCE systems during an emergency event, and/or support containment of environmentally hazardous material.	
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.10 Unplanned Hydrocarbon Release: Loss of Control of Suspended Load from Okha Lifting Operations (MEE-08)

Context		
Lifting Operations – Section 3.6.9.1	Physical Environment – Section 4.4 Biological Environment – Section 4.5 Socioeconomic and Cultural – Section 4.6 Values and Sensitivities – Section 4.7	Stakeholder Consultation – Section 5

Risk Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	Marine Sediment	Water Quality	Air Quality (incl Odour)	Ecosystems/ Habitat	Species	Socioeconomic	Decision Type	Consequence	Likelihood	Risk Rating	ALARP Tools	Acceptability	Outcome
Hydrocarbon release from subsea equipment to the marine environment and atmosphere (MEE-02).	-	X	X	X	X	X	X	B	C	1	M	LCS GP PJ RBA CV	Acceptable if ALARP	EPO 19
Hydrocarbon release from topsides equipment to the marine environment and atmosphere (MEE-03).	-	X	X	X	X	X	X	B	D	1	M			

Description of Source of Risk

Background

The Okha FPSO is equipped with four rotating cranes and one overhead crane. Lifting takes place between supply vessels and laydown areas or between laydown areas. The main deck cranes are equipped with 'lock-out' zones, to prevent lifting over sensitive areas or equipment without additional controls being implemented and to eliminate the potential for a crane to strike other structures or obstacles, such as the flare tower or Accommodation block.

Lifting operations performed using the Okha FPSO or visiting vessel cranes could potentially lead to dropped objects impacting assets (topsides equipment, subsea infrastructure) inside the Okha FPSO 500 m PSZ. This may lead to a hydrocarbon loss of containment from topsides or subsea infrastructure. Loss of suspended load has been identified as a MEE (MEE-08). A loss of suspended load may arise from:

- lifting equipment failure
- facility lifting operations.

A number of common failure causes due to human error and SCQ failures are presented in the generic Human Error and SCE failure bowties in Section 6.8.11.

Loss of Suspended Load – Credible Hydrocarbon Spill Scenario

The potential outcome of a loss of control of a suspended load is a topsides and/or subsea flowlines and riser loss of containment. Refer to Section 6.8.4 and Section 6.8.5 for a description of subsea equipment and topsides loss of containments scenarios, respectively.

Decision Type, Risk Analysis and ALARP Tools

Woodside has a good history of implementing industry standard practice in FPSO operation. In the company's 60-year history, it has not experienced any loss of control of suspended load events that have resulted in significant releases or significant environmental impacts.

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<u>Decision Type</u>

Decision Type B has been applied to this risk under the Guidance on Risk Related Decision Making (Oil and Gas UK 2014). This reflects the complexity of the risk, the higher potential consequence and stakeholder implications should the event be realised. To align with this decision type, a further level of analysis has been applied using risk-based tools including the bowtie methodology (described in Section 2.7.3) and hydrocarbon spill trajectory modelling. Company values were also considered in the demonstration of ALARP and acceptability.

The release of hydrocarbons as a result of subsea loss of containment is considered a MEE (MEE-08). The hazard associated with this MEE is the hydrocarbon inventory of subsea flowlines and risers, or topsides process and non-process hydrocarbons equipment.

Note that Woodside has assessed the environment consequence of a worst-case credible loss of containment from subsea equipment (refer MEE-02) as 'C' as per the Woodside Risk Matrix. Woodside has also assessed the reputational and brand consequences associated with this release and concluded that the event results in a 'B' level consequence, and hence meets Woodside's definition of a MEE (refer to Section 2.7.2).

<u>Quantitative Spill Risk Assessment</u>

Credible worst-case hydrocarbon scenarios for MEE-02 and MEE-03 are considered to apply to a loss of control of suspended load, as they may credibly arise from damage to hydrocarbon containing subsea infrastructure within the 500 m PSZ and Okha FPSO topsides infrastructure. Refer to Sections 6.8.4 and 6.8.5 for additional information on quantitative spill risk assessments for these scenarios.

<u>Consequence</u>

The spatial extent and fate (incl. weathering) of the spilled hydrocarbon were considered during the impact assessment for a worst-case loss of suspended load. These considerations were informed primarily by the outputs from the numerical modelling studies undertaken by RPS, available information on environmental sensitivities that may credibly be impacted in the event of a worst-case spill (Section 6.8.1) and relevant literature and studies considering the effects of hydrocarbon exposure.

<u>Likelihood</u>

In accordance with the Woodside Risk Matrix, given prevention and mitigation measures in place (i.e. design, inspection and maintenance), the likelihood has been taken as Highly Unlikely (1).

Consequence Assessment

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

- Subsea Equipment Loss of Containment, Section 6.8.4 (MEE-02)
- Topsides Loss of Containment, Section 6.8.5 (MEE-03).

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

MEE-08 Loss of Control of Suspended Load from Okha Lifting Operations – Risk Analysis

Bowtie risk analysis was undertaken to assess MEE-06; refer to Figure 6-26, Figure 6-27, Figure 6-29, and Figure 6-30 for bowtie diagrams.

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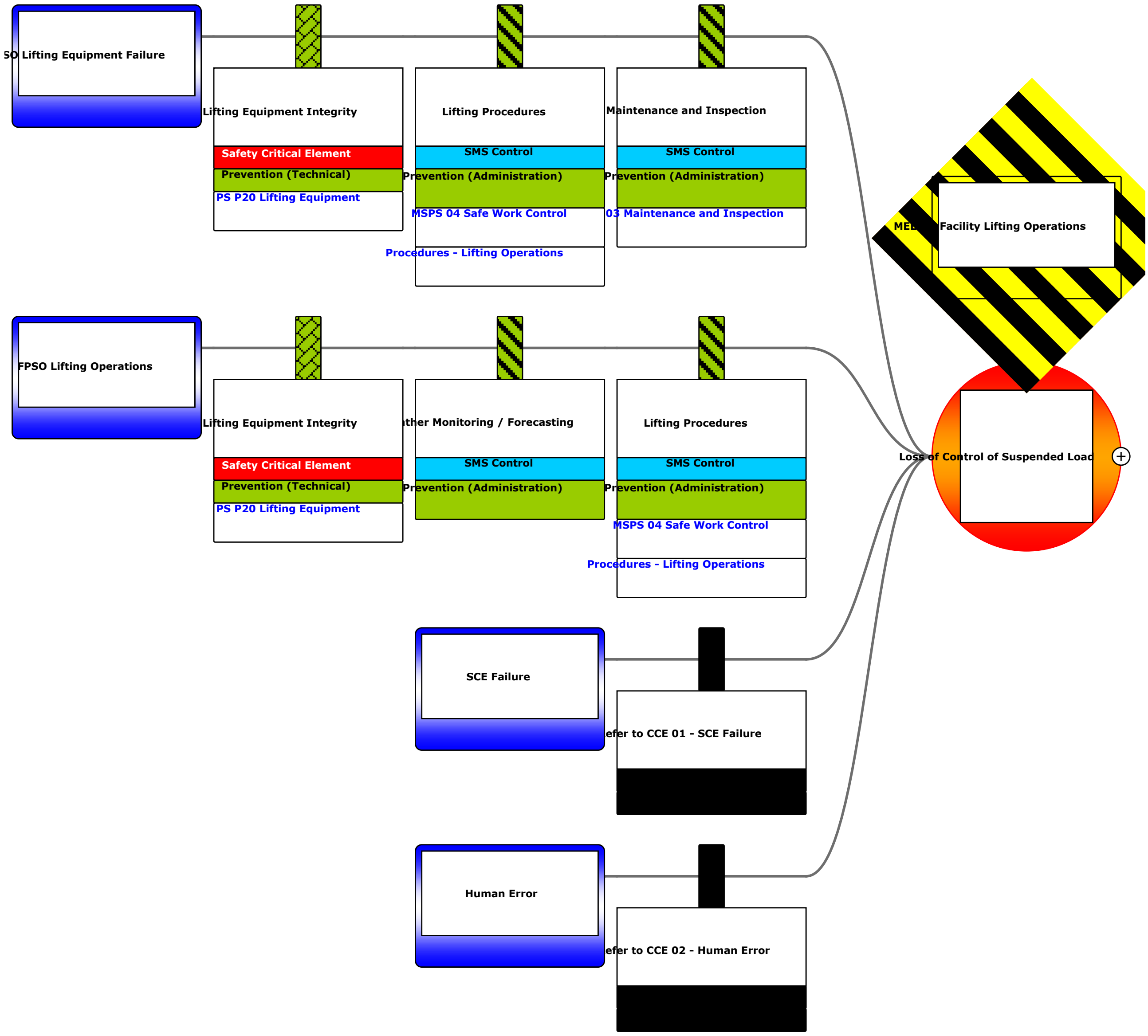

Figure 6-31: MEE-08 Loss of Control of Suspended Load from Okha Lifting Operations (Causes 1–4)

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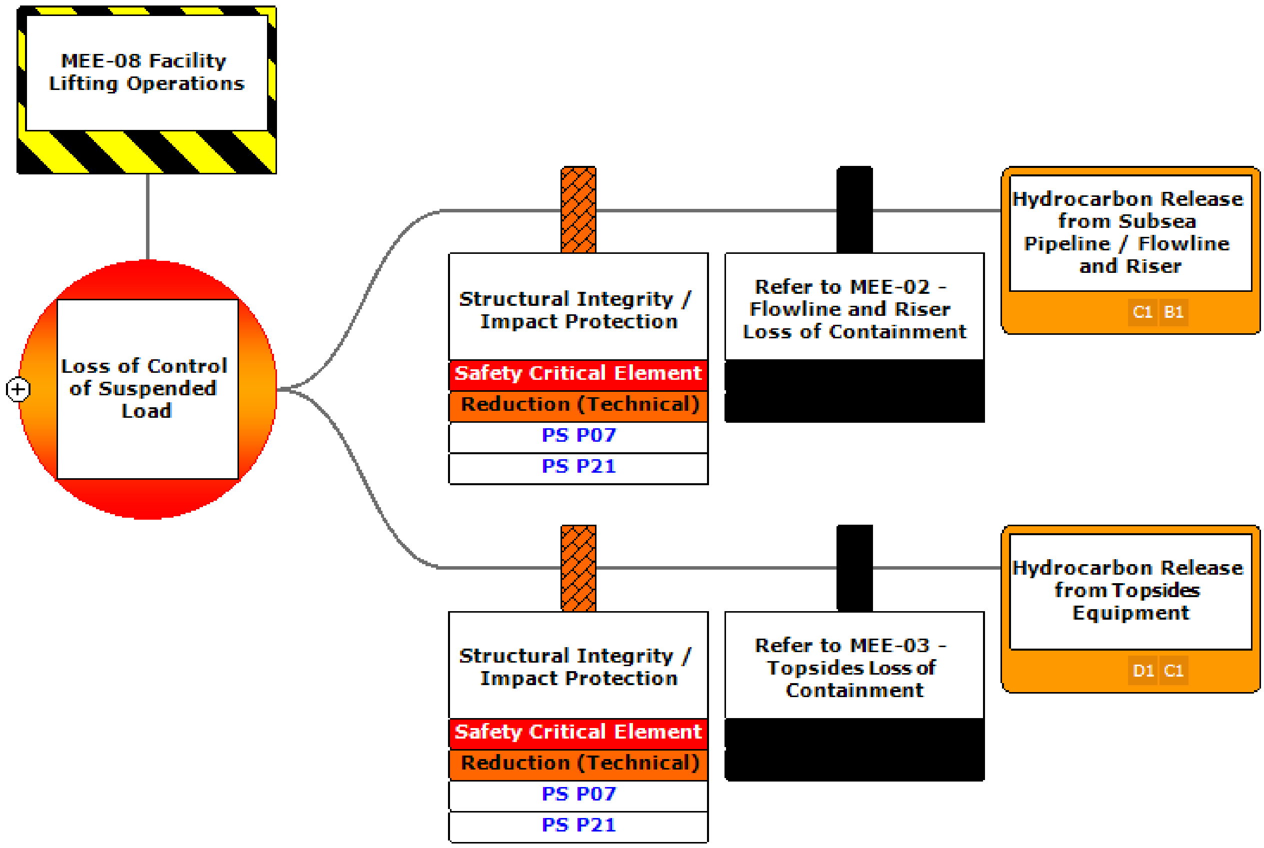

Figure 6-32: MEE-08 Loss of Control of Suspended Load from Okha Lifting Operations (Outcomes)

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MEE-08 Loss of Control of Suspended Load from FPSO – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Substitution				
Engineering Controls	Maintain integrity of FPSO lifting equipment to prevent lifting equipment failure or dropped/swinging loads that could result in a MEE.	P20 – Lifting Equipment	Prevention (Technical)	Yes **C 19.1**
Mitigating Barrier – Safety and Environmental Critical Elements				
Impact Protection	Maintain structural integrity (impact protection) to ensure availability of critical systems during a major accident or environment event and prevent structural failures from contributing to escalation of a MEE.	P07 – Topsides Surface Structure P21 – Substructures	Reduction (Technical)	Yes **C 19.2**
Emergency Response	Maintain environmental incident response equipment to enact the Okha Pollution First Strike Plan.	E05 – Environmental Incident Response Equipment	Mitigation (Technical)	Yes **C 12.4**
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha facility to: – identify hazards that have the potential to cause a MAE – detail assessment of MAE risks – describe the physical barriers SCEs and the safety management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP.	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**

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MEE-08 Loss of Control of Suspended Load from FPSO – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***
	Thus, contributing to management of associated potential environmental consequences of MAEs.			
Procedures and Administration	Incident reports are raised for unplanned releases within event reporting system.	Woodside Health, Safety and Environment Event Reporting and Investigation Procedure	Prevention / Mitigation (Administration) Control based on Woodside standard and regulatory requirements. Good practice that operators identify, report and learn from unplanned release events. Supports compliance with regulatory reporting requirements.	Yes **C 8.5**
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • Engineering Standard Lifting Equipment • MSPS 03 Maintenance and Inspection • MSPS 04 Safe Work Control • Procedures – Lifting Operations.	Engineering Standard Lifting Equipment MSPS 03 Maintenance and Inspection MSPS 04 Safe Work Control Lifting Operations Procedure	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Emergency Response and Contingency Planning	Implement management systems to maintain: • M06 – Emergency Preparedness • Okha Emergency Response Plan • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Pollution Emergency Arrangements – Australia.	MSPS 06 – Emergency Preparedness Okha ERP Okha Oil Pollution First Strike Plan (Appendix H) Oil Pollution Emergency Arrangements – Australia	Mitigation (Administration)	Yes – See Section 7 Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.
Risk Based Analysis				
For risks identified as MEEs, a more detailed risk based Bowtie Analysis (as outlined in Section 2.7.3), has been used to identify, analyse and demonstrate ALARP controls for each MEE. ALARP controls have been selected following				

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MEE-08 Loss of Control of Suspended Load from FPSO – Demonstration of ALARP ALARP Control Measures				
Hierarchy	***Control / Barrier***	***SCE / Management System Reference***	***Type of Effect (Table 6-21)***	***Control Adopted***

hierarchy of control principles and considers independence of each barrier and their type of effect in controlling the hazardous event.

Application of Woodside Risk Management Procedures and implementation of the Okha FPSO Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

For each SCE, detailed requirements for equipment functionality, availability, reliability and survivability are incorporated into SCE technical Performance Standards which also include the relevant assurance tasks (e.g. inspection, maintenance, testing and monitoring requirements) to ensure technical integrity.

Bowtie analysis was undertaken to assess MEE-08; refer to Figure 6-31 and Figure 6-32 for bowtie diagrams.

A quantitative spill risk assessment was undertaken (refer Section 6.8.1).

Company Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

Societal Values

Refer to Company Values in demonstration of ALARP for MEE-01 (Section 6.8.3).

ALARP Statement

On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of a Highly Unlikely likelihood unplanned hydrocarbon release as a result of a loss of control of suspended load.

The principle of inherent safety and environmental protection is based on the prevention of the MEE through design of the Okha FPSO and ensuring the equipment is operated within the design envelope through operating practices and assurance through maintenance and inspection. If a loss of control of suspended load occurs, mitigation measures are in place to minimise the consequence by limiting the inventory which can be released and implementing remediation.

The controls in place for prevention and mitigation of MEEs are specified and assured through implementing the Okha Safety Case, SCE management procedures including technical performance standards for SCEs and MSPS for Safety Critical Procedures.

The application of Woodside Risk Management Procedures and implementation of the Okha Safety Case ensures the continuous identification of hazards, systematic assessment of risks and ongoing assessment of alternative control measures to reduce risk to ALARP, which includes:

- ongoing hazard identification, risk assessment and the identification of control measures
- ongoing integrity management of hardware control measures in accordance with the SCE technical performance standards which define requirements to be suitably maintained, such that they retain effectiveness, functionality, availability and survivability.

Given the controls in place to prevent and control loss of containment events and mitigate their consequences, alongside procedural control of Okha operations, it is considered that MEE risk associated with Loss of Control of Suspended Load is managed to ALARP.

Demonstration of Acceptability

Loss of suspended load has been evaluated as having a ‘Moderate’ risk rating (via the consideration of applicable MEEs). As per Section 2.8.2, Woodside considers ‘Moderate’ risk ratings as broadly acceptable if the adopted controls are implemented. Due to the consequence associated with MEE-08, Decision Type B has been applied, and ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for and the alternative control measures are grossly disproportionate to the benefit gained.

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Acceptability is demonstrated with regard to the considerations described in Section 6.8.3 (MEE-01) (the considerations include principles of ESD, internal context, external context and other requirements (includes laws, policies, standards and conventions)).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 19 Loss of suspended load from OKHA FPSO risks to the environment limited to High through maintenance of prevention and mitigative barriers during the Petroleum Activities Program.	**C 19.1** Maintain integrity of FPSO lifting equipment to prevent lifting equipment failure or dropped/swinging loads that could result in a MEE.	**PS 19.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P20 – Lifting Equipment to: – prevent lifting equipment failure or dropped/swinging loads that could result in a MEE by maintaining lifting equipment integrity.	Refer to **MC 12.1**
	C 19.2 Maintain structural integrity (impact protection) to ensure availability of critical systems during a major accident or environment event and prevent structural failures from contributing to escalation of a MEE.	**PS 19.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P07 – Topsides Surface Structure and P21 – Substructures to: – provide and maintain structural integrity to support SCE systems under all design conditions through service life – prevent structural failure from contributing to the escalation of an MEE by providing support/protection of SCE systems during an emergency event, and/or support containment of environmentally hazardous material.	Refer to **MC 12.1**
	Refer to **C 12.4**	Refer to **PS 12.4**	Refer to **MC 12.1**
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Refer to **C 8.5**	Refer to **PS 8.5**	Refer to **MC 8.5**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

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6.8.11 MEE Common Cause Event Failure Mechanisms: SCE Failure CCE-01 and Human Error CCE-02

This section presents common mode failure causes and controls applicable across MEEs, which are also observed within the bowties of the MEEs discussed within sections above. Controls, EPSs and MC presented within this section are also considered relevant to MEE-01 to MEE-08.

Okha: Major Environment Event Datasheet	
MEE Number	All
Hazard Description	Generic SCE failure
Hazard Description	
Hazard Overview and Scope	
There are a number of causes which contribute to failures of SCEs and other systems which might protect against a MEE. These include: • maintenance errors • defects • electrical supply failure • hydraulic supply failure • adverse environmental conditions. The generic SCE failure bowtie (Figure 6-33 and Figure 6-34) illustrates the causes, outcomes and the controls in place to manage these failure mechanisms.	

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Hazard Management (Bowtie Diagrams)

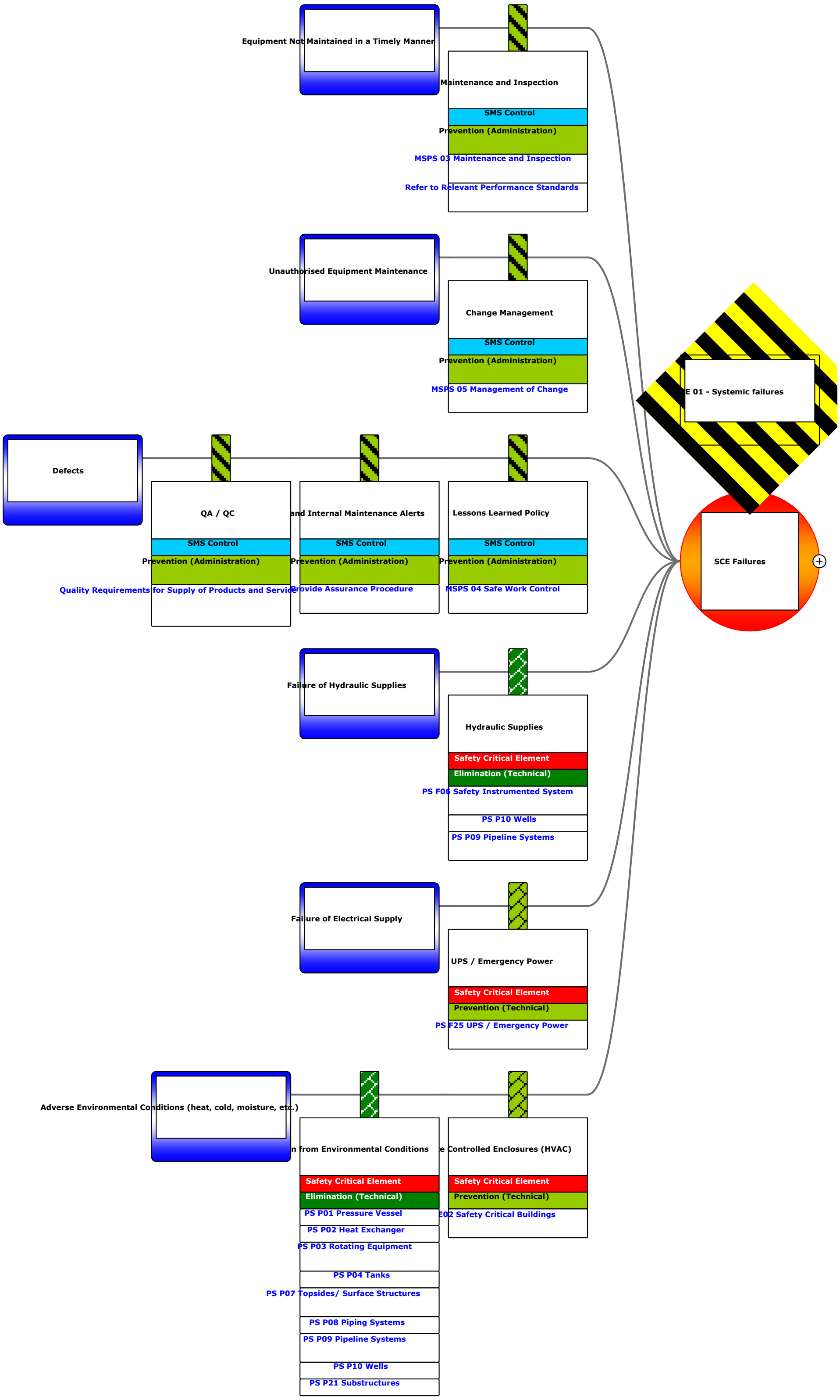

Figure 6-33: Generic Bowtie – SCE Failures (Causes)

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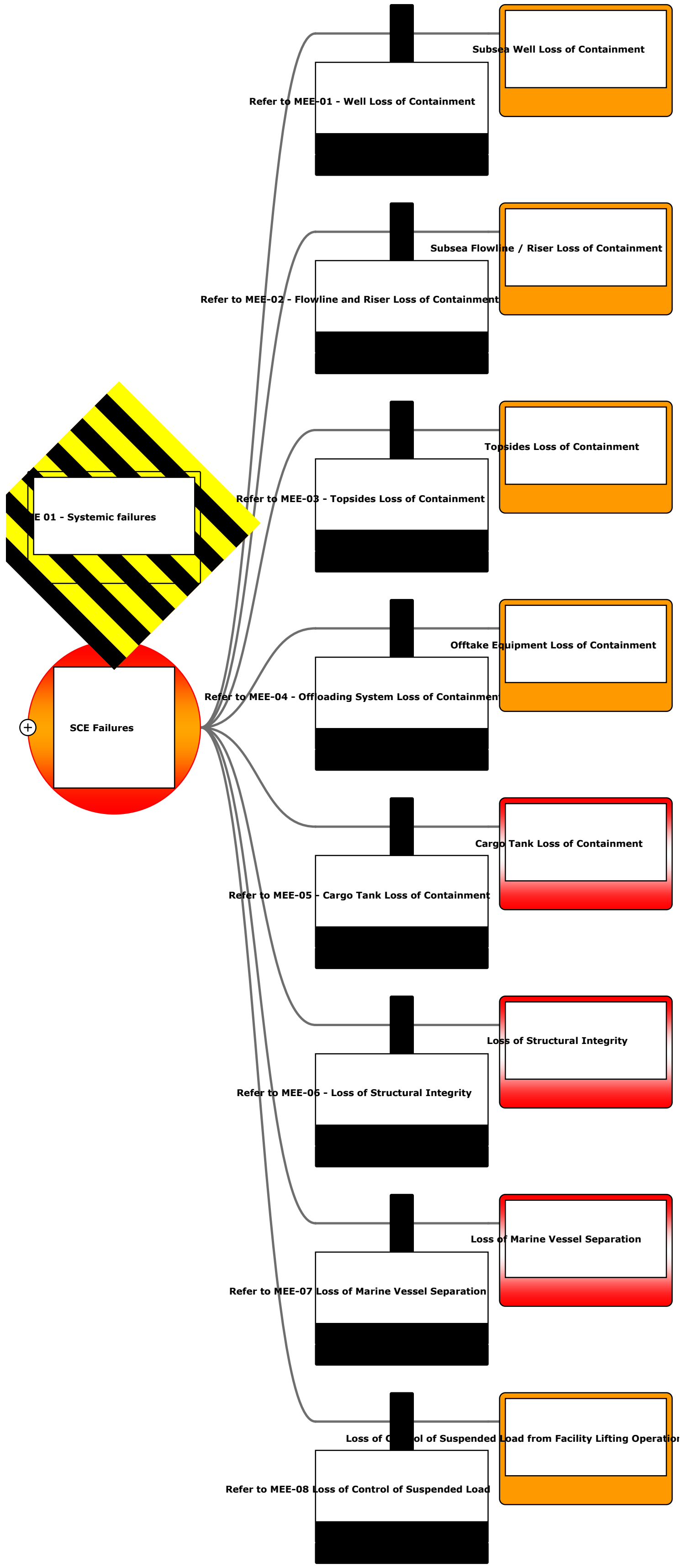

Figure 6-34: Generic Bowtie – SCE Failures (Outcomes)

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CCE-01 Safety Critical Equipment Failure Risk Analysis and Demonstration of ALARP ALARP Control Measures				
Hierarchy	**Control / Barrier**	**SCE / Management System Reference**	**Type of Effect (Table 6-21)**	**Control Adopted**
Preventive Barriers – Safety and Environmental Critical Elements				
Elimination	Maintain hydraulic supplies (e.g. to support Safety Instrumented Systems and actuation of SCE valves/isolations).	F06 – Safety Instrumented System P10 – Wells	Elimination (Technical)	Yes **C 20.1**
	Maintain protection from environmental conditions.	P01 – Pressure Vessel P02 – Heat Exchanger P03 – Rotating Equipment P07 – Topsides Surface Structure P08 – Piping Systems P09 – Pipeline Systems P10 – Wells P21 – Substructures	Elimination (Technical)	Yes **C 20.2**
Substitution	n/a	No elimination or substitution controls were identified beyond those incorporated in design.		
Engineering Controls	Maintain UPS / emergency power system to supply Essential safety systems.	F25 – UPS / Emergency Generation Systems	Prevention (Technical)	Yes **C 20.3**
	Maintain climate controlled enclosures to protect essential equipment from adverse environmental conditions.	E02 – Temporary Refuge	Prevention (Technical)	Yes **C 20.4**
Mitigating Barrier – Safety and Environmental Critical Elements				
Mitigation	n/a	No mitigation controls were identified beyond those incorporated in design.		
Legislation Codes and Standards				
Procedures and Administration	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009: • Accepted Safety Case for the Okha facility to; – identify hazards that have the potential to cause a MAE; – detail assessment of MAE risks; and – describe the physical barriers SCEs and the safety	Okha Safety Case	Prevention (Administration) Control based on legislative requirements – must be adopted	Yes **C 12.6**

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CCE-01 Safety Critical Equipment Failure Risk Analysis and Demonstration of ALARP ALARP Control Measures				
Hierarchy	**Control / Barrier**	**SCE / Management System Reference**	**Type of Effect (Table 6-21)**	**Control Adopted**
	management systems identified as being required to reduce the risk to personnel associated with a MAE to ALARP; thus, contributing to management of associated potential environmental consequences of MAEs.			
Management System Specific Measures: Key Standards or Procedures				
Procedures and Administration	Implement management systems to maintain: • MSPS 03 Maintenance and Inspection • MSPS 04 Safe Work Control • MSPS 05 Management of Change • Quality Requirements for Supply of Products and Service • Provide Assurance Procedure	• MSPS 03 Maintenance and Inspection • MSPS 04 Safe Work Control • MSPS 05 Management of Change • Quality Requirements for Supply of Products and Service • Provide Assurance Procedure)	Prevention (Administration)	Yes – See Section 7 Implementation Strategy.
Risk Evaluation				
Refer to MEEs.				

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
Refer to relevant MEE EPOs: • **EPO 12** • **EPO 13** • **EPO 14** • **EPO 15** • **EPO 16** • **EPO 17** • **EPO 18** • **EPO 19**	**C 20.1** Maintain hydraulic supplies (e.g. to support Safety Instrumented Systems and actuation of SCE valves/isolations).	**PS 20.1** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F06 – Safety Instrumented System; and P10 – Wells to together: – maintain hydraulic supplies (e.g. to support Safety Instrumented Systems and actuation	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		of SCE valves/isolations).	
	C 20.2 Maintain protection from environmental conditions.	**PS 20.2** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • P01 – Pressure Vessel • P02 – Heat Exchanger • P03 – Rotating Equipment • P04 – Tanks • P07 – Topsides Surface Structure • P08 – Piping Systems • P09 – Pipeline Systems • P10 – Wells • P21 – Substructures for each SCE to protect equipment from adverse environmental conditions (e.g. heat, cold, moisture, chemical reaction/incompatibility).	Refer to **MC 12.1**
	C 20.3 Maintain UPS / emergency power system to supply Essential safety systems.	**PS 20.3** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • F25 – UPS/Emergency Generation Systems – to provide continuous supply of power (emergency generation and UPS to Essential loads following a total (mains) power failure.	Refer to **MC 12.1**
	C 20.4 Maintain climate controlled enclosures to protect essential equipment from adverse environmental conditions.	**PS 20.4** Integrity will be managed in accordance with SCE Management Procedure (Section 7.1.5) and SCE technical Performance Standard(s) to prevent environment risk related Damage to SCEs for: • E02 – Temporary Refuge – to protect essential equipment from adverse environmental	Refer to **MC 12.1**

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Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
		conditions/fire and explosion.	
	Refer to **C 12.6**	Refer to **PS 12.6**	Refer to **MC 12.6**
	Mitigation – hydrocarbon spill response	Refer to Appendix D for discussion around the ALARP assessment of controls related to hydrocarbon spill response.	

Okha: Major Environmental Event Datasheet	
MEE Number	ALL
Hazard Description	Generic Human Errors – Degradation Factors
Hazard Ref ID	N/A

HAZARD DESCRIPTION

Hazard Overview

There are a number of causes of human errors which contribute to MEEs, or which can result in failure or degradation of the barriers in place to protect against MEEs. These are presented in the following bowtie pages and include:

- task issues, e.g. poor task design; time pressures, task complexity
- poor physical interfaces / working environment
- provision of inappropriate tools for the task
- communication errors, i.e. poor-quality information, lack of clarity in instructions
- operator failings, e.g. competence, fitness, impairment or fatigue
- organisational issues, e.g. peer pressure, poor safety culture, inadequate supervision, lack of clarity on roles and expectations.

The Generic Human Errors bowtie illustrates the causes, outcomes and the barriers in place for these failure mechanisms. Human Errors are managed solely via the WMS (no SCEs) and the bowtie is included in this section for completeness. Refer to Section 7 for applicable Management System Procedures.

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HAZARD MANAGEMENT (BOWTIE DIAGRAMS)

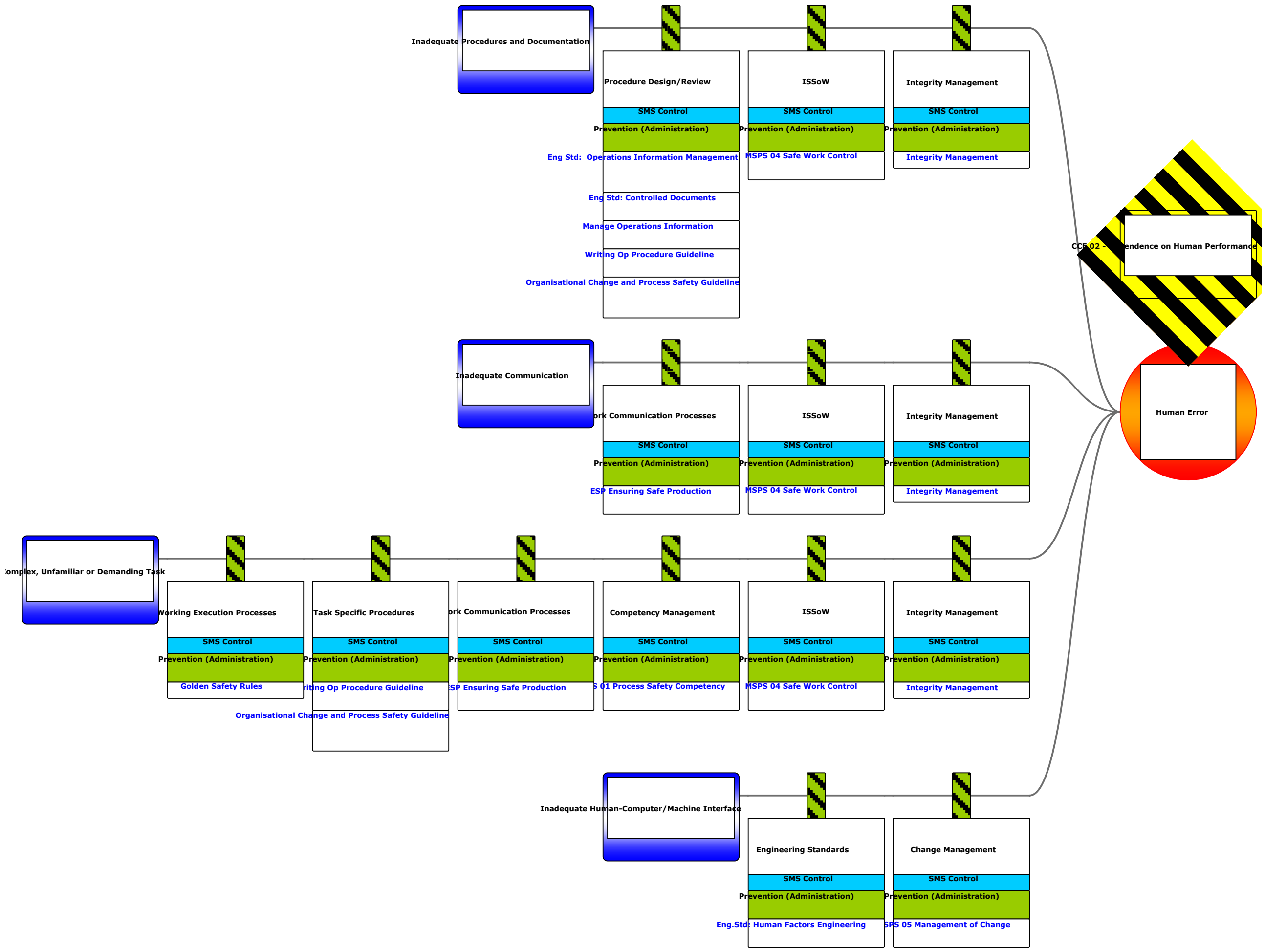

Figure 6-35: Generic Bowtie – Human Error (Causes 1–4)

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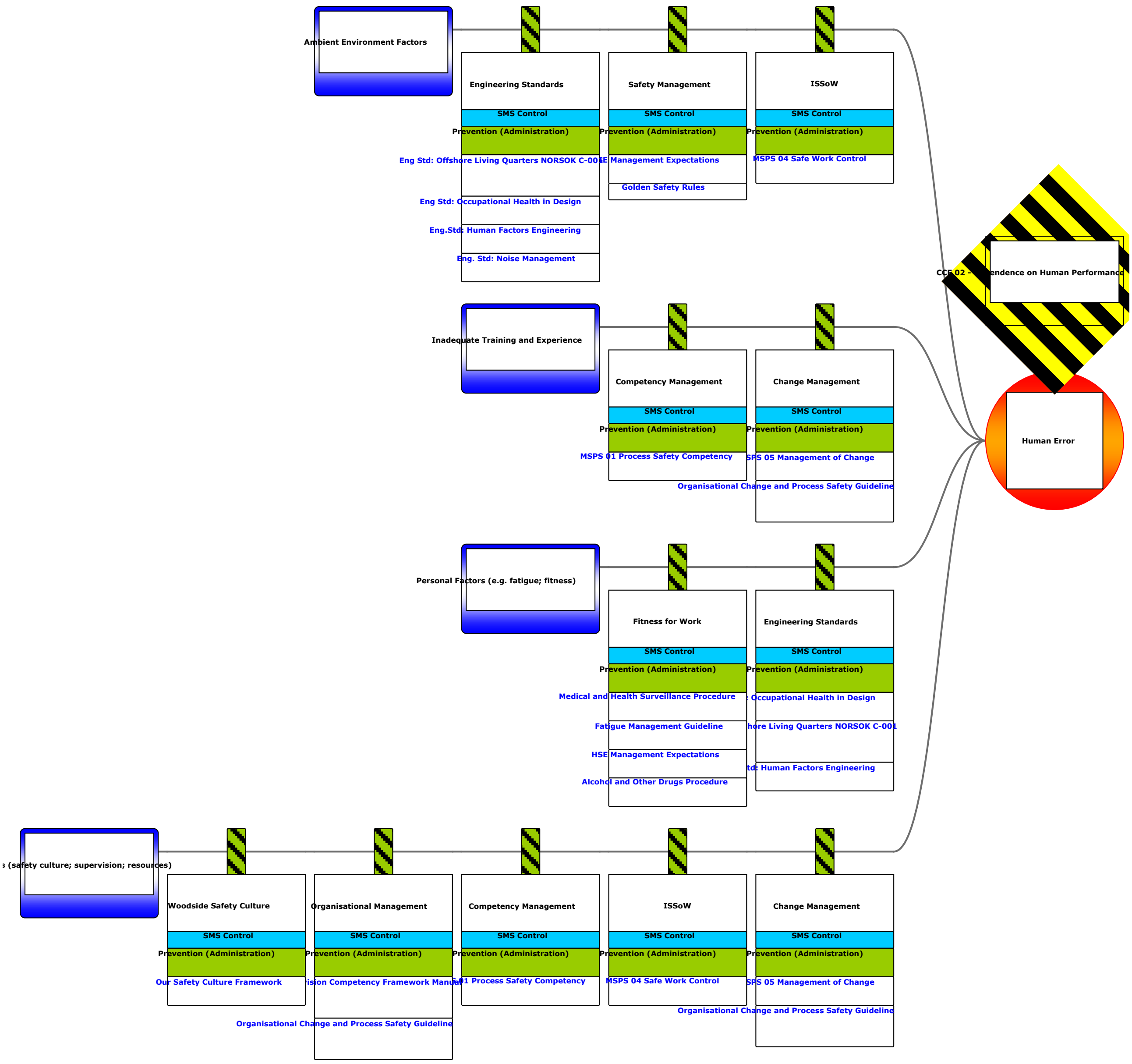

Figure 6-36: Generic Bowtie – Human Error (Causes 5–8)

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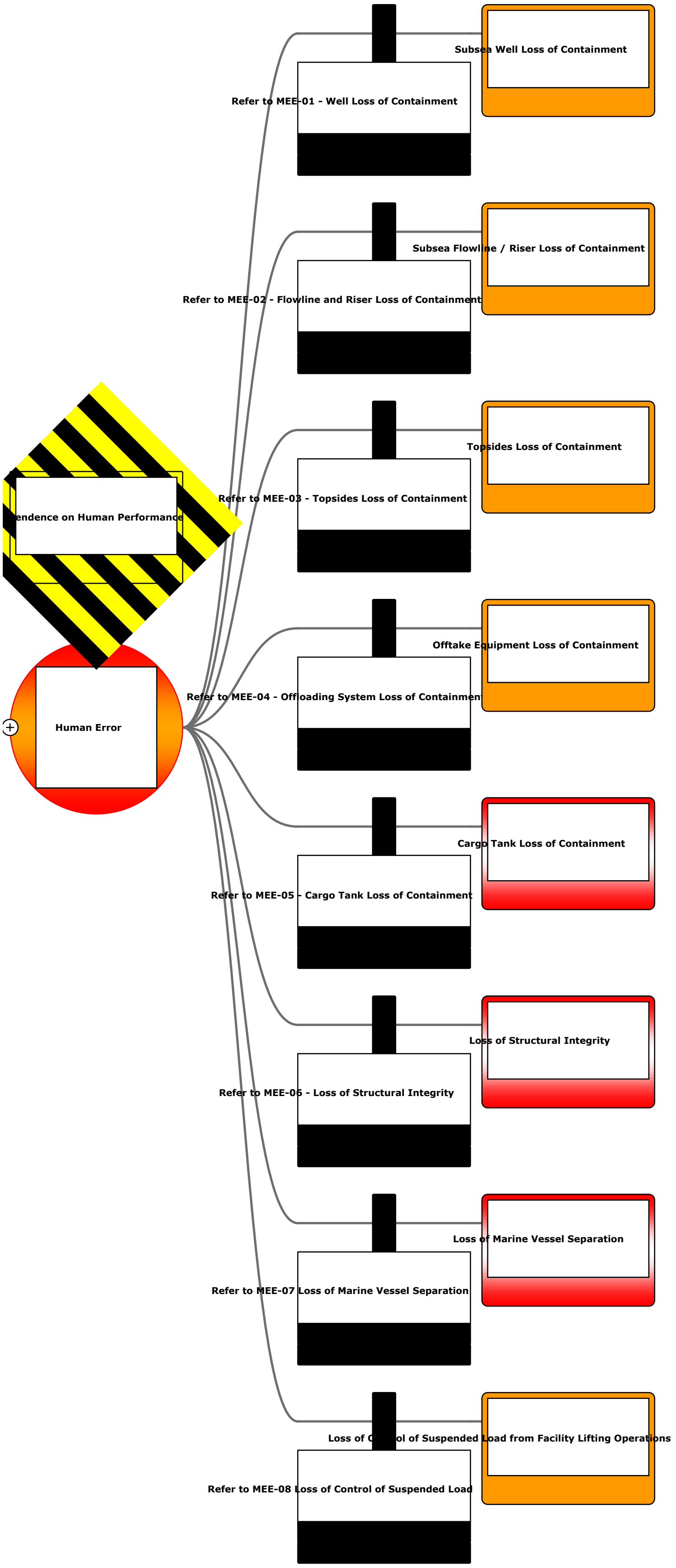

Figure 6-37: Generic Bowtie – Human Error (Outcomes)

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7. IMPLEMENTATION STRATEGY

Regulation 14 of the Environment Regulations requires an EP to contain an implementation strategy for the activity. The implementation strategy for the Petroleum Activities Program confirms fit-for-purpose systems, practices and procedures are in place to direct, review and manage the activities so that environmental risks and impacts are continually being reduced to ALARP and are acceptable, and that EPOs and EPSs outlined in this EP are achieved.

Woodside, as Operator, is responsible for ensuring that the Petroleum Activities Program is managed in accordance with this implementation strategy and the WMS (see Section 1.10).

7.1 Systems, Practice and Procedures

All operational activities are planned and carried out in accordance with relevant legislation and internal environment standards and procedures identified in this EP (Section 6).

Processes are implemented to verify controls to manage environmental impacts and risks to:

- a level that is ALARP and acceptable
- meet EPOs
- comply with EPSs defined in this EP.

The systems, practices and procedures that will be implemented are listed in the EPSs contained in this EP. Document names and reference numbers may be subject to change during the statutory duration of this EP; this is managed through a change register and management of change process (Section 7.1.3). Further information regarding some of the key systems, practices and procedures relevant to implementation of this EP is provided below.

7.1.1 WMS Operate Processes

Under the WMS Operate Activity (see Section 1.10 for an overview of the WMS), there are four overarching processes; those directly relevant to the implementation of this EP and environmental management during the Petroleum Activities Program are described below (Operate Plant Process and the Maintain Assets Process).

7.1.1.1 Operate Plant

The objective of the Operate Plant Process is to ensure production is carried out in a safe, efficient, reliable and economic manner, and that all required process variables are within allowable limits. This ensures the potential for unplanned (accident/incident) events that may impact the environment are minimised.

The Operate Plant Process develops key activities to support ongoing production activities in order to ensure the facility is operated within the Basis of Design. The process also identifies required production routines, routine execution, recording of data gathered and formulation of remedial activities. The Operate Plant Process includes the Integrated Safe System of Work (ISSoW) system (described below).

In addition, the Operating Practice MSPS (M02) is in place to assure operating practices are in place, such that:

- integrity-critical operating procedures are available, accurate, up to date, understood and used
- safe operating and technical integrity limits are defined, understood and the process is managed within these limits.

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Integrated Safe System of Work

The ISSoW Procedure outlines the key activities required to achieve effective management of permit-controlled work on the facility. The ISSoW process is a management system for all work and is a key element in ensuring the safety of personnel, protection of the environment and technical integrity of the facility.

Work within the facility 500 m PSZ and operations within the vicinity of the connected flowlines is controlled in accordance with ISSoW.

The ISSoW system takes a risk-based approach to activities, thus tasks with higher levels of risk are subjected to greater scrutiny and control. The ISSoW system also allows for low risk routine tasks to be carried out with adequate but minimal administration. The prime objective of ISSoW is to ensure work other than normal operations is properly planned, risk assessed, controlled, coordinated and safely executed. It provides a methodical approach to identifying hazards, assessing risks, and creating and supporting permits to work and associated certificates.

In keeping with ALARP principles, this system is critical to ensuring the appropriate level of hazard identification and risk assessment is carried out for activities performed on the facility.

In addition, the Safe Work Control MSPS (M04) is in place to assure effective safe work control, permit to work and task risk management arrangements are in place and followed to control the risks arising from work activities.

7.1.1.2 Maintain Assets

The Maintain Assets Process aims to improve the reliability and availability of plant and equipment (which includes that required for safe operation) through well managed and planned execution of maintenance that promotes a proactive maintenance culture.

Maintenance, inspection and testing systems and procedures are in place to safeguard the integrity of the facility. The maintenance strategy for the facility is based on optimising safety, minimising environmental impact and maximising production. Maintenance practices used to establish well managed maintenances strategies, planned execution and improvement are described in the Maintenance of Assets Procedure.

A risk-based approach is used as the basis for establishing and prioritising inspection, maintenance and testing requirements at the facility. Equipment is assessed to establish equipment criticality with respect to the consequences and likelihood of equipment failure. This informs determination of appropriate maintenance and inspection activities. Maintenance activities are allocated risk rankings according to the criticality of equipment, to ensure high risk maintenance work orders are completed as a priority.

A computerised maintenance management system (CMMS) provides a database called SAP-PM that contains facility registers, equipment details, spare parts data and associated planned maintenance tasks. This system is used to plan, monitor and record maintenance activities. The system provides a variety of reports that enable monitoring and assessment of maintenance activities.

SCE Technical Performance Standards identify SCEs and associated assurance activities. These activities are identified in the CMMS and given the appropriate priority (Technical Integrity status). Refer to Sections 2.7.5 and 7.1.5 for more detail on SCE Technical Performance Standards and how they differ from EPSs required by the Environment Regulations. SCE Technical Performance Standards form a key component in the processes and systems implemented by Woodside to maintain safety and environment critical plant and equipment.

In addition, the Maintenance and Inspection MSPS (M03) is in place to assure that the necessary inspection and maintenance requirements are identified and carried out to maintain the integrity of SCEs and SCQs.

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7.1.2 Process Safety Management

To ensure that Woodside protects the safety, security and health of its employees, contractors, the environment and assets, Woodside has adopted the Energy Institute's Process Safety Management (PSM) framework within its Process Safety Management Procedure which sets out a disciplined framework for managing the integrity of systems and processes that handle hazardous substances over the production (and exploration) lifecycle. It deals with the prevention and control of events that have potential to release hazardous materials and energy.

PSM consists of four main focus areas. Each focus area contains a number of PSM requirements that define key aspects required to ensure that PSM is integrated through the organisation. There are twenty PSM requirements. The focus areas and requirements are shown in Figure 7-1.

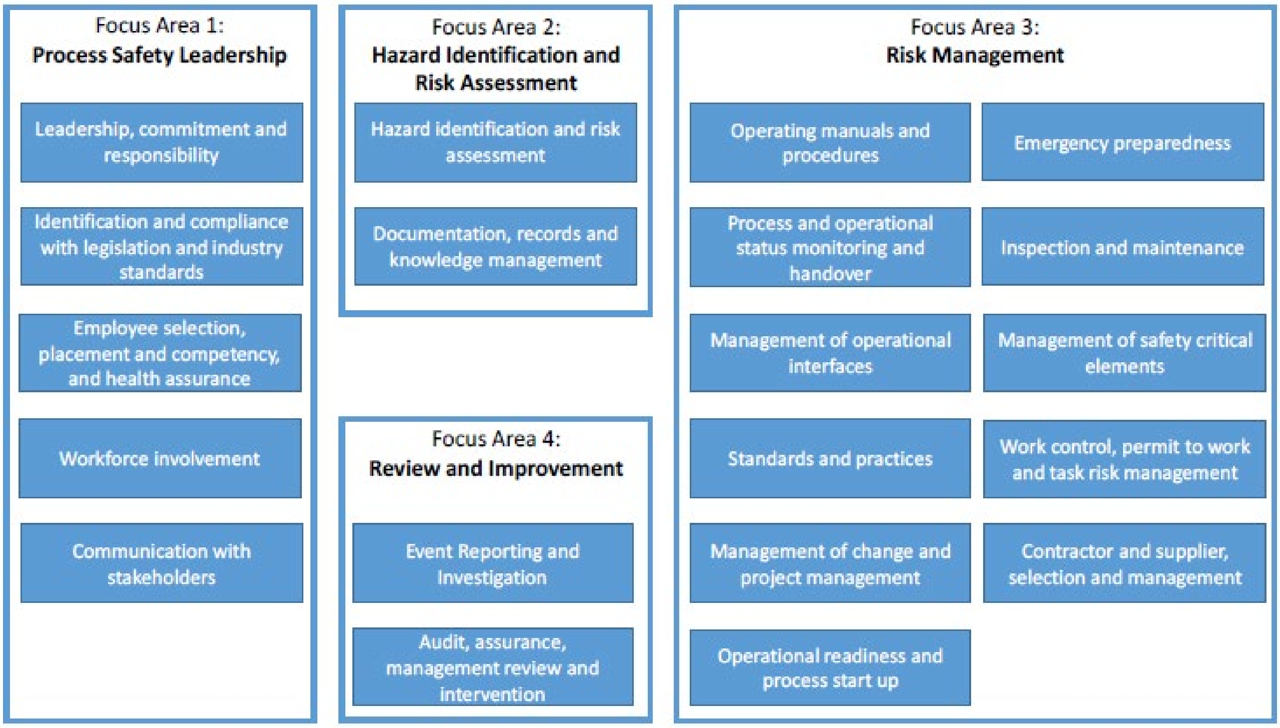

Figure 7-1: Process safety management focus areas

7.1.2.1 Woodside Safety Culture Framework

Woodside's 'Our Safety Culture' framework (shown in Figure 7-2) promotes a strong HSE culture and is a key enabler for effective process safety management. This framework outlines the expected behaviours for everyone including supervisors and managers/executives, and is openly discussed as part of inductions, training and development.

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Theme	Everyone	Supervisors	Managers/Executives
Standards	Follow rules	Ensure compliance	Set high standards
Communication	Speak up	Encourage the team	Communicate openly
Risk management	Be mindful	Promote risk awareness	Confront risk
Involvement	Get involved	Involve the team	Involve the workforce

Figure 7-2: Woodside 'Our Safety Culture' framework

7.1.3 Risk Management

Risk management processes and practices are applied on an ongoing basis to design, production and maintenance activities at the Okha facility to manage risks to personnel, assets and the environment.

Potential environmental consequences and impacts from the Okha facility are risk assessed and controlled in accordance with the Woodside risk management processes described in Section 2.2 of this EP (Environmental Risk Management Methodology).

The results of the Okha facility ENVID are described in Section 6 and in the facility Environmental Impacts and Risk Register. This register, in conjunction with the EP, provides a demonstration that environmental risks have been identified, and that appropriate controls are in place to manage those risks to a level that is acceptable and ALARP throughout the life of the facility.

A number of other risk management tools and techniques are used by the Okha facility to manage environmental and other risks on a routine basis during operational, maintenance and inspection tasks. Examples include:

- the processes outlined in Section 2
- risk management tools including: ISSoW tools, e.g. Hazard Identification and Risk Assessments and Level 2 Risk Assessments, Operational Risk Assessments, the technical Management of Change (MoC) system (Section 7.1.4), and Step back 5 x 5
- integrity review studies, HAZIDs and Hazard Operability studies.

These tools, risk and integrity management practices are described further in the Okha Facility Safety Case, WOMP, and the Control of Operational Risk Procedure.

In addition, other risk sub-processes and practices are also applied within Woodside on an ongoing basis to manage different types of risk. A summary of those relevant to the Petroleum Activities Program is provided below. Woodside's risk management processes (refer to Section 2.2.1), along with the supporting risk sub-processes and practices discussed in this section, ensure the environmental impacts and risks of the activity continue to be identified and reduced to a level that is ALARP.

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7.1.3.1 Management of Risks – Contracting and Procurement

Suppliers and contractors play a significant role in meeting the resource needs of Woodside's operations, including the facility operations. Effective management of environmental risks in contracts is achieved by setting clear expectations and managing environmental risks throughout the duration of the contract. Environmental risks in contracts are managed under the Contracting and Procurement Procedure supported by the Health, Safety and Environment in Contracting Guideline. The guideline provides a risk-based approach to contractor selection and management, and is aligned with 'HSE Management – Guidelines for Working Together in a Contract Environment' International Association of Oil and Gas Producers, Report No. 423.

The Engineering Standard Quality Requirements for Supply of Products and Services defines specific quality requirements for engineering contracts and purchase orders. The specified quality control requirements in the Standard are required to be complied with as applicable to the scope of supply.

7.1.3.2 Management of Risks – Subsea Activities

Subsea activities are managed in line with the Subsea and Pipelines Integrity Management Procedure which defines the practices and technical requirements that must be applied to deliver and safeguard integrity of the subsea equipment and pipelines during the facility lifecycle. It provides the relationship between the PSM Framework (including management of change) and Subsea and Pipelines Group services processes.

IMMR activities are managed under the Mange IMMR Work Procedure. Risk assessments are conducted as required under this procedure.

These requirements are supported by implementation of the Subsea Construction and Inspection, Maintenance and Repair Environment Screening Questionnaire tool. The screening questionnaire is used to understand the scope of the activity, potential environmental impact and if additional regulatory approvals are required. To achieve this, the questionnaire captures key project information such as seabed disturbance, chemical usage and waste. This information is used by an environment focal point to determine if further assessment is required. For projects that have the potential for environmental impact, an assessment is undertaken against this EP and other Woodside environmental requirements. If determined by the Subsea and Pipeline Environment Screening Questionnaire process, an EP MoC review (as per Section 7.1.4) may be undertaken to confirm if the level of environmental risk warrants revision and resubmission of an EP. Environmental questionnaires are maintained in the Subsea and Pipeline (SSPL) Environment Project Register.

Key environmental requirements and regulatory commitments are communicated to project teams and incorporated into key project documentation where applicable and required (i.e. not addressed via existing Woodside practices).

7.1.3.3 Management of Risks – Major Projects

Major projects are required to follow the Appraise and Develop Management Procedure and the Opportunity Management Framework. This procedure defines the requirements to deliver a commercially valuable production facility or modify to an existing facility. The process workflow requires integration of work from various functions utilising their people and processes, including Environment, for example HSE philosophy and regulatory approval requirements.

These requirements are supported by implementation of the Brownfields Environment Screening Questionnaire tool. The screening tool is used to determine if a project has the potential for environmental impact or requires additional regulatory approvals. For projects that have the potential for environmental impact, an environmental focal point is assigned and the risks and impacts assessed against the facility EP and other Woodside environmental requirements.

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Key environmental requirements and regulatory commitments are communicated to project teams and incorporated into key project documentation where applicable and required (i.e. not addressed via existing Woodside practices).Where it is identified that the project scope has the potential to result in significant modification or change to the facility description provided in the EP, or where potential significant new environmental risks or impacts or significant increases in an existing environmental risk or impact are identified, an EP MoC review (as per Section 7.1.4) may be undertaken to confirm if the level of environmental risk warrants revision and resubmission of an EP.

7.1.3.4 Management of Risks – Well Integrity

Wells are managed throughout their lifecycle in line with the Well Lifecycle Management Procedure. This procedure provides the basis for ensuring well integrity in accordance with the Process Safety Management Procedure.

In addition, wells are required to have a regulator-accepted Well Operations Management Plan to demonstrate that well integrity risks are managed to ALARP levels. Wells tied back to the facility are managed under a WOMP.

Management of operating wells can be formally transferred from Operations to the Drilling and Completions (D&C) Function for activities such as well intervention and workover. Where activities are undertaken by the D&C Function, the risks are managed under the D&C Risk Management Procedure, which specifically addresses the risk of loss of containment from a well or well related equipment. This procedure supplements the Woodside Risk Management Procedure.

7.1.3.5 Management of Risks – Marine Services

Woodside's Marine Services Function provides a platform for the conduct of safe and efficient Marine Operations across Woodside through the Marine Services Management. A set of procedures that support vessel assurance and management (including HSE and quality [HSEQ] management) are in place to ensure marine operations are conducted in a safe and efficient manner, and in accordance with regulatory requirements. Management of subsea activities on subsea support vessels is managed by the SSPL Function.

More details on vessel assurance and the communication of environment requirements to vessels are provided in Section 6.8.9.

Vessel masters are required to request clearance from the facility Offshore Installation Manager (OIM) or delegate prior to entering the 500 m PSZ.

7.1.3.6 Management of Human Factor Related Risks

The term 'human factors' is used to describe the consideration of people as part of complex systems. Woodside defines 'human factors' as follows: 'human factors uses what we know about people, organisation and work design to influence performance.

As outlined in Section 6.8.9, human factors can contribute to MEEs, or result in failure or degradation of the controls in place to protect against MEEs. The WMS includes a number of procedures designed to manage human factors related risks and prevent incident causation.

7.1.4 Change Management

Woodside's Change Management Procedure describes Woodside's requirements for change management at Woodside owned or controlled operations/sites.

Change management is used where there is no existing approved business baseline, such as a process, procedure or accepted practice, or where conformance with an approved baseline is not possible or intended; for example, due to equipment fault or failure or a recently discovered issue which will take time to rectify. Change management is also used when the baseline is changed (e.g.

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the process is modified). It applies to management of temporary, permanent, planned or unplanned change encompassing one or more of the following:

- plant (equipment, plant, technology, facilities, operations or materials)
- projects (budget, schedule)
- people (organisation structure, performance, roles)
- process (WMS content, processes, procedures, standards, legislation, information).

Woodside's change management process hierarchy is depicted in Figure 7-3. The hierarchy has been developed with sub-processes to address the different types of change performed at Woodside.

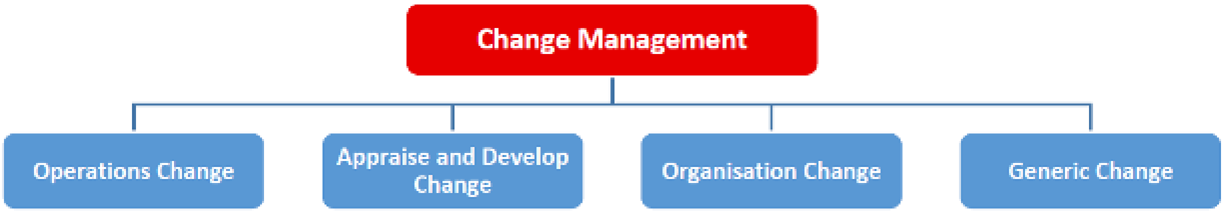

Figure 7-3: Change management hierarchy

To help manage the day to day operation of the facility, Woodside has developed a Golden Safety Rules Booklet, which provides a summary of mandatory requirements for safety in the workplace and includes guidance for managing changes that have a Health, Safety, Integrity and/or Environment impact.

7.1.4.1 Technical Change Management

Technical changes within the Operations Division are managed using the Management of Change – Assets Procedure. The objective of the Management of Change – Assets Procedure is to ensure HSE risks associated with both realised and potential changes, including any failure to meet the facility SCE Technical Performance Standards, are identified, assessed and reduced to ALARP (Section 7.1.5 provides further information on management of SCE Technical Performance Standards).

Assessed changes must be recommended, agreed and decided upon based on the assessed current level of risk, as defined by Woodside's Technical Decision Authority matrices.

The management of change requirements contained in the Process Safety Management Procedure and Management System Performance Standard M05 Management of Change are considered when conducting any changes with the potential to impact process safety.

The Engineering Management Procedure specifies key requirements of engineering related changes, and requires that engineering Technical Decisions are agreed, recommended and decided at the appropriate engineering authority level according to the risk. Change management and risk assessment include consideration of applicable legislation/regulation.

Change is also managed under management system requirements set out as part of major projects (Brownfields), wells integrity, subsea and pipelines integrity management and marine management system. Change management includes consideration of regulatory requirements, managed in accordance with the Regulatory Compliance Management Procedure.

In addition, the Management of Change MSPS (M05) is in place to assure process safety risks arising from change (temporary and permanent) are systematically identified, assessed and managed.

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7.1.4.2 EP Management of Change and Revision

Woodside's Environmental Approval Requirements Australia Commonwealth Guideline provides guidance on the Environment Regulations that may trigger a revision and resubmission of the EP to NOPSEMA. The document also provides guidance on what may constitute as new source-based or receptor-based impacts and risks, or a significant increase in an existing source of environmental risk (to provide context in determining if EP resubmission is required under Regulations 8 and 17 of the Environment Regulations).

Minor EP changes, where a review of the activity and the environmental risks and impacts of the activity shows the changes do not trigger regulatory requirements to resubmit the EP, will be considered a 'minor revision'.

Changes with potential to influence minor or technical changes to the EP text are tracked in management of change records, project records, or the Production EP Updates Register, and incorporated during internal updates of the EP or the five-yearly revision.

In accordance with the requirements of Regulation 19 of the Environment Regulations, Woodside will also submit to NOPSEMA a proposed revision to this EP at least 14-days before the end of each period of five years, commencing on the day on which the original and subsequent revisions of the EP are accepted under Regulation 11 of the Environment Regulations.

7.1.4.3 Change of Titleholder's Nominated Liaison Person

In the event of a change to Woodside's nominated liaison person, or a change to the contact details for the titleholder or the nominated liaison person, Woodside will notify NOPSEMA of the change in writing as soon as practicable.

7.1.5 Management of SCE Technical Performance Standards and Management System Performance Standards

7.1.5.1 Management System Performance Standards (MSPS)

Woodside ensures safety critical management processes function as required through the application of MSPS. MSPS are developed and owned at non-facility specific level (i.e. pan Woodside) and include assurance checks for the key requirements of the applicable management system.

Individual facilities demonstrate conformance against the MSPS through the conduct of reviews. Non-conformances against an MSPS are internally managed in accordance with the Woodside Management System.

7.1.5.2 SCE Technical Performance Standards

An SCE is defined by Woodside as a hardware barrier, the failure of which could cause or contribute substantially to, or the purpose of which is to prevent or limit the effect of a MAE/MEE, or Process Safety Event.

Woodside identifies/develops, implements, monitors/assures and verifies/optimises SCEs by applying SCE technical Performance Standards as described in the Safety and Environment Critical Element (SCE) Management Procedure. Key elements of the procedure are summarised in Table 7-1.

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Table 7-1: Safety and Environment Critical Element Management Procedure summary

Identify/Develop	**Identify SCE –** SCEs must be identified from the facilities PSRAs (e.g. Formal Safety Assessments) (Section 2.2). The identification of SCEs for which Performance Standards are required are part of the formal safety and environmental risk assessment processes. Woodside's Global Performance Standards (based on industry and Woodside Standards) should be used for preliminary selection of SCEs. **Complete Engineering Design Studies –** Engineering design studies must be completed to demonstrate that SCE Performance Criteria specified in the global Performance Standard and/or determined by PSRA will be met by the facility design, allowing for normal SCE degradation in operation. The studies must establish the testing and inspection tasks required to assess performance against the criteria. The scope and frequency of SCE Assurance Tasks are guided by the Global Performance Standard and may require designated Engineering Design Studies. Studies should include Reliability Centred Maintenance, Risk Based Inspection and Safety Instrumented Function studies to determine the Assurance Task scope and frequencies, RBI plans, and classification and implementation requirements for instrumented safeguarding. **Develop Performance Standards –** Facilities must develop Performance Standards for all SCEs by: • selecting the applicable Global Performance Standard (including Assurance Tasks) • considering facility specific requirements and applicable regulatory requirements • adding the specific data from the facility Engineering Design Studies and PSRA to compile scope and frequency of SCE assurance activities.
Implement	**Identify SCE in Asset Register –** SCEs must be uniquely identified on the asset register and assigned Performance Standard flags. **Develop Testing, Inspection and Maintenance Programs –** SCE assurance tasks are developed into maintenance procedures. **Implement Testing, Inspection and Maintenance Programs –** SCE testing, inspection and maintenance requirements must be implemented in the CMMS (Section 7.1.1.2).
Maintain/Assure	**Execute Testing, Inspection and Maintenance Programs** – On completion of SCE assurance tasks, results must be recorded with all relevant detail, assessed for conformance with the Performance Criteria and any follow on correction work identified. **Conduct Fitness for Service (FFS) Assessment –** In some instances, an engineering FFS assessment may be required to determine whether equipment has failed its performance standard requirements, e.g. assessment of corrosion defects following inspection of piping. Detailed results of FFS assessment may be recorded out of CMMS. **Response to SCE Failure** – SCE failure (technical Performance Standard non-conformance) is a failure to achieve the given Performance Criteria. SCE failures must be managed in accordance with a structured review process. This process may require the application of the facility Manual of Permitted Operation (MOPO) which provides prescriptive guidelines to be followed in the event of a reduction in the performance of an SCE, or managed in accordance with the Management of Change – Assets Procedure (Section 7.1.4). **Internal Reporting** – SCE failure/damage and SCE demands must be reported in accordance with the Health Safety and Environment Event Reporting and Investigation Procedure (Section 7.7.4). **External Reporting** – External notification obligations for SCE failure/damage must be understood (i.e. based on local regulatory requirements). External communications must be in accordance with the health safety and environment event reporting and investigation procedure (Section 7.7.4). **Manage and Analyse Results** – The results from assurance tasks must be accurately recorded to support data analysis. Analysis will enable appropriate action to be taken to minimise future failure recurrences, and enable assessment of overall system performance and reliability to verify SCE effectiveness in revealing failures and to allow predictive maintenance.
Verify/ Optimise	**Review SCE Performance –** SCE performance reviews must be conducted to ensure requirements for maintaining SCE performance are being met. **Manage Change –** Any change to the Performance Standards must be conducted in accordance with the Change Management Procedure (Section 7.1.4).

SCE Technical Performance Standards are a statement of the performance required of an SCE (e.g. functionality, availability, reliability, survivability), which is used as the basis for establishing agreed assurance tasks and managing the hazard. An assurance task is an activity carried out by the operator to confirm that the SCE meets, or will meet, its SCE technical Performance Standard. Examples of assurance tasks include inspection routines, maintenance activities, test routines, instrumentation calibration and reliability monitoring.

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These assurance tasks are identified in the CMMS, flagged against their associated technical Performance Standard, and given the appropriate priority (defined as Technical Integrity). Management systems are in place to manage the completion of maintenance including that required for Technical Integrity assurance.

SCE failure (non-conformance) is a failure to achieve a given performance criteria of the SCE technical Performance Standard. SCE failures are managed in accordance to the process defined in the SCE Management Procedure. This process may require the application of: the facility Manual of Permitted Operation (MOPO) which provides prescriptive guidelines to be followed in the event of a reduction in the performance of an SCE in specific defined circumstances; or, if the MOPO does not cover the event, according to procedures for the assessment and management of operational risk.

Events related to non-conformances with SCE Technical Performance Standards are classed for internal reporting processes as:

- ‘Failure of SCE’ Event – a failure to meet key requirements or performance criteria stated within the SCE Performance Standard, taking into account any redundancy inherent in the SCE; or
- ‘Damage to SCE’ Event – a failure to meet key requirements or performance criteria stated within the SCE technical Performance Standard (i.e. ‘Failure of SCE’ event), taking into account any redundancy inherent in the SCE, where the increase in potential risk is current and material enough to require an immediate control action to be implemented to maintain risks to an acceptable level.

Both ‘Failure of SCE’ and ‘Damage to SCE’ Events are internally reported as Hazard Events. Where ‘Failure of SCE’ or ‘Damage to SCE’ leads to a loss of hydrocarbon containment, or a release of energy, it is internally reported (and externally where relevant) as a Loss Of Primary Containment or Environmental Spill event, depending on the nature of the release.

Additionally, ‘Damage to SCE’ Events for the SCEs identified in the MEE bowties may equate to a breach of EPOs and/or EPSs. The review to identify ‘Damage to SCE’ Events for external reporting considers whether the hazard event is relevant to environmental key requirements/ performance criteria of the SCE technical Performance Standard and whether the event poses a risk to achieving EPOs and EPSs. External notification reporting requirements for ‘Damage to SCE’ events are outlined within Section 2.7.5.

There may also be planned changes/deviations from SCE Technical Performance Standards, these are managed via procedures for the assessment and management of operational risk, and endorsed in accordance with the engineering management procedures (described further within Section 7.1.4). This management process ensures risks (including environment) are managed so that the planned change/deviation does not result in unacceptable impact or risk, remains ALARP and regulatory requirements are met.

An additional class of SCE exists to capture environment critical emissions monitoring and control equipment and is also managed under this process. The ‘P31 technical Performance Standard – Environmental Emissions Monitoring and Controls’ includes equipment required to comply with environmental legislation, regulations, approval conditions or requirements which apply to the Okha facility. Examples include equipment to monitor flaring emissions. Improvement work is ongoing to optimise management of equipment required for regulatory compliance, where the risk of failure is less than that required to trigger requirement for an SCE technical Performance Standard (i.e. flare metering is not a control for MEEs). This parallel process will facilitate similar management as currently in place for P31 (managed under SCE technical Performance Standards processes) to set out key performance requirements for applicable equipment, maintenance/assurance tasks and to support change management, prioritisation and governance.

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7.2 Organisation Structure

The following Woodside organisational structure provides leadership and direction for operation of the Okha facility and environmental performance:

- the Chief Operations Officer (COO) reports to the Chief Executive Officer
- the Senior Vice President (SVP) Australia Operating Unit and Business Unit SVPs or Vice Presidents (VPs) report to the COO
- the General Manager Environment reports to the VP HSEQ
- the Production Environment Manager reports to the General Manager Environment
- the Asset Manager reports to the SVP Australia Operating Unit
- the functional support teams report to the corresponding Business Unit SVP or VP
- all Production facilities are supported by a team of environmental professionals who report to the Production Environment Manager
- all facilities are supported by other Woodside functional teams including:
  - **Engineering** – supports operating assets in terms of engineering standards/guidelines and governance processes, systems, applications and specialist personnel to support these standards/guidelines
  - **HSEQ Support** – provides specific guidance and access to specialist HSEQ resources including assistance for governance and training, as well as guidance on Woodside HSEQ standards
  - **Subsea** – responsible for the installation and IMMR activities on subsea infrastructure including facility structures, flowlines, manifolds and subsea isolation valves to ensure integrity
  - **Drilling and Completions** – ensures the safe planning and execution of drilling (note drilling is excluded from the scope of this EP), completion and work over operations
  - **Brownfields** – responsible for the engineering, construction and execution of small projects on operational facilities to ensure ongoing integrity and safe operation
  - **Marine Group** – responsible for chartering vessels to support Woodside's offshore production facilities including vessels to aid emergency response
  - **Aviation Group** – provides personnel transport, material transport, emergency evacuation and search and rescue capabilities.

A simplified chart of the structural organisation of the Okha facility is shown in Figure 7-4.

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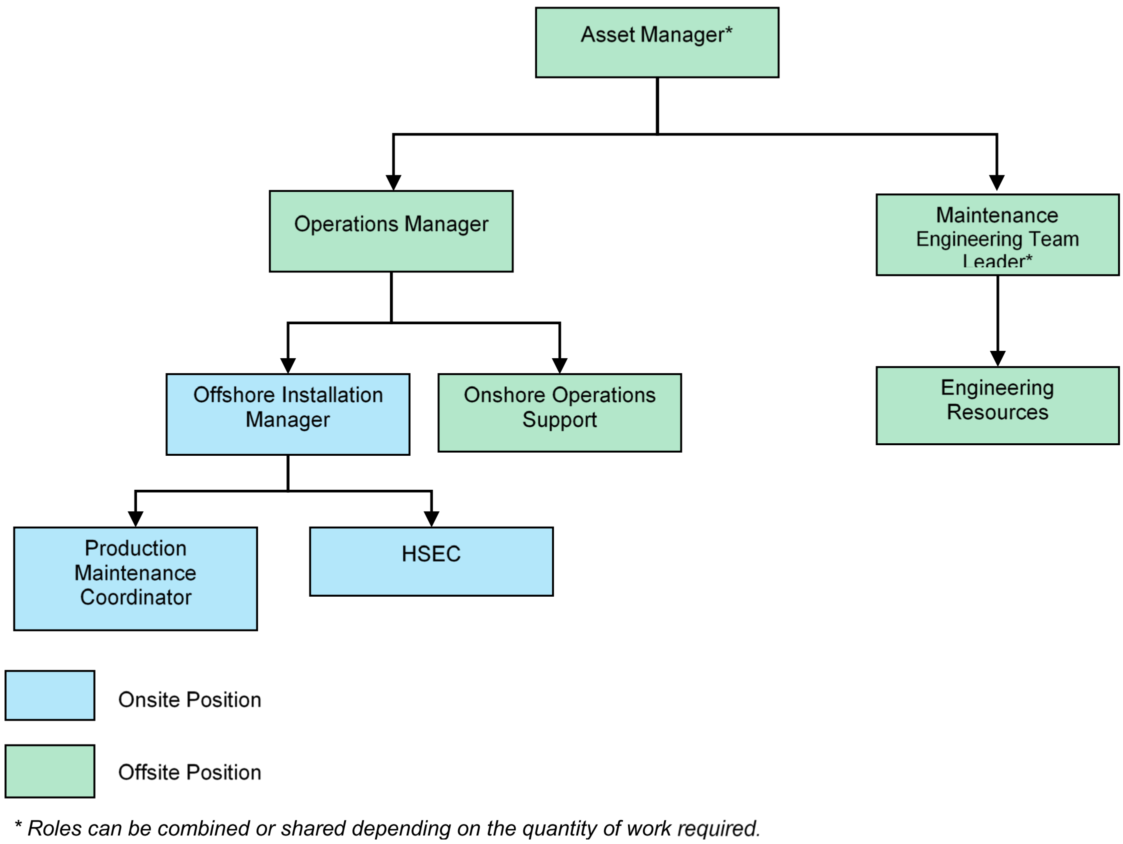

Figure 7-4: Operations Division organisational structure (simplified to show key relevant roles)

7.3 Roles and Responsibilities

As required by Regulation 14(4), this section of the implementation strategy establishes a clear chain of command that sets out the roles and responsibilities of personnel in relation to the implementation, management and review of the EP, ranging from senior management to operational personnel on the Okha FPSO and support vessels.

Key roles and responsibilities for Woodside and Contractor personnel in relation to the implementation, management and review of this EP are described below in Table 7-2. Roles and responsibilities for hydrocarbon spill preparation and response are outlined in Table 7-2 and the Woodside Oil Pollution Emergency Arrangements (Australia) (OPEA (Australia)). Roles and responsibilities for facility emergency response are outlined in the Okha Facility Safety Case and are consistent with the Okha Emergency Response Plan.

It is the responsibility of all Woodside employees and contractors to apply the Woodside Corporate Health, Safety, Environment and Quality Policy (Appendix A) in their areas of responsibility.

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Table 7-2: Roles and responsibilities

Title (role)	Responsibilities related to EP
All Personnel	
All facility based personnel and onshore support personnel	• understand the Woodside standards and procedures that apply to their area of work • understand the environmental risks and control measures that apply to their area of work • carry out assigned activities in accordance with approved procedures and the EP • follow instructions from relevant supervisor with respect to environmental protection • cease operations which are deemed to present an unacceptable risk to the environment • participate in environmental assurance activities and inspections as required • prompt reporting of environmental hazards/incidents to their supervisor and assist in event investigation.
Office-based Personnel	
Asset Manager	• accountable for ensuring all necessary regulatory approvals are in place to operate • approves (decides on) the content to be contained in the Environment Plan • accountable for managing the asset throughout its operations in accordance with legislative/regulatory requirements (including this EP) and WMS requirements. Has responsibility for subsea infrastructure from the point of structural disconnection from the Riser Turret Mooring (RTM) • approves written notification to regulatory authorities (for example notifications to NOPSEMA under this Environment Plan) • agrees facility key performance indicators (KPIs), including environment KPIs and is accountable for their achievement • accountable for incident notification, reporting and investigation in line with regulatory requirements, the WMS and EP requirements • decides on technical decisions where required based on assessed current level of risk • responsible for continuous improvement of operations of the facility, including environmental performance • NWS Asset Manager accountable for described petroleum activities occurring within WA-3-L and WA-5-L.
Operations Manager	• responsible for the operation of the facility in accordance with legislative/regulatory requirements (including this EP) and the WMS • accountable for aspects of integrity management • accountable for conformance to production Operations processes including ISSoW • decides on technical decisions where required based on assessed current level of risk • communicates changes relevant to the EP to the Production Environment team.
Maintenance Engineering Team Lead	• responsible for safeguarding process safety with respect to the asset • ensure technical integrity risks are identified, managed and reduced to ALARP • recommends technical decisions where required based on assessed current level of risk

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Title (role)	Responsibilities related to EP
Integrity Authorities (Technical Integrity Custodians, Technical Authorities and Engineering Authorities)	• agree technical integrity decision based on assessed current level of risk when discipline owner • undertake process safety responsibilities as defined under the Woodside process safety framework.
Production Environment Manager	• facilitate Production Division environmental approval documentation and timely submission in accordance with regulatory requirements • facilitate review of the EP, including five-yearly revision and in relation to any technical decisions or proposed changes to operations • ensure Production Division understands and adheres to legislative and regulatory environment requirements, EP requirements and the environmental requirements of the WMS • guide and drive environmental management across the Production Division • Monitor and communicate to internal stakeholders all relevant changes to legislation, policies, regulator organisation that may impact the EP or business • develop and maintain appropriate Production environmental processes and procedures • develop (in conjunction with divisional management) environment improvement plans and KPIs • monitor and review progress against environmental improvement plans and KPIs with divisional management to drive continuous improvement • implement effective Production environmental training.
Production Environment Adviser	• ensure Production Division understands legislative and regulatory requirements, EP requirements and WMS environmental requirements • ensure personnel have access to the EP and understand their environmental responsibilities under the EP • manage change relevant to the EP in accordance with the Regulations and the EP • implement environment improvement plans and monitor progress • liaise with applicable regulatory authorities as required • develop, maintain and roll-out environmental training inductions, refreshers and material to promote environmental awareness • ensure environmental monitoring, offshore inspections, and reporting is undertaken as per the requirements of this EP • communicate findings to management • coordinate and monitor closeout of corrective actions • assist with review, investigation and reporting of environmental incidents. • liaise with Woodside contractors and Subsea Support Bessel crew to communicate and ensure their understanding of IMMR related requirements under this EP • conduct IMMR related environment training, messaging/communications, event reporting and investigation as required • ensure environmental inspections/audits are undertaken as per the requirements of the EP

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Title (role)	Responsibilities related to EP
	• ensure environmental incident reporting meets regulatory requirements (as described within the EP) and WMS requirements • assurance that all IMMR activities are provided by the EP.
Subsea and Pipelines (IMMR) Activity Manager	• ensure IMMR activities undertaken in line with EP commitments • manage IMMR change requests for the activity and notify the Subsea and Pipelines Environment Adviser of any scope changes in a timely manner • provide sufficient resources to implement the EP requirements • monitor and close out corrective actions raised from IMMR environmental inspections/audits or incidents • responsible for governance of IMMR related activities for Subsea Support Vessels.
Corporate Affairs Adviser	• stakeholder identification and consultation • reporting on stakeholder consultation • ongoing stakeholder liaison as required.
Woodside Marine Services Function	• responsible for pre-charter assurance for all contracted vessels • conduct of ongoing operational assurance of vessels contracted through Woodside Marine, to confirm vessels operate in compliance with relevant legislation, rules and Woodside Marine Charterers Instructions in order to be able to meet safety, navigation, operational and emergency response requirements.
Contractor Sponsors	• ensure implementation of EP for the contractor's scope of work • ensure contractors have adequate environmental capability in order to execute their respective scopes of work • review contractor environmental performance as required.
Offshore-based Personnel	
Offshore Installation Manager	• in charge of the Okha facility and the field to the point of structural disconnection from the RTM • accountable for implementation of the EP at the facility • ensures offshore personnel comply with regulatory/legislative requirements (including the EP) and the WMS • responsible for Area Operations compliance with Technical Integrity requirements including Management of Change process, Permit to Work process and MOPO and process safety requirements • single point responsible person for the coordination of simultaneous activities • accountable for the performance and development of direct reports, ensuring operator capability and competency across all shifts and ensuring the skill requirements of the Production division are being met. • implement relevant offshore environment initiatives and review environmental performance to drive continuous improvement. • ensure effective communication with workforce on environmental performance • ensure incidents are reported and investigated in line with WMS and EP requirements, with appropriate actions initiated and closed out

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Title (role)	Responsibilities related to EP
	• lead response efforts (as Incident Controller) in managing emergency or crisis scenarios • ensure exercises and drills are conducted in a manner to assure the facility's ability to respond effectively to an emergency • decides on technical decisions where required based on assessed current level of risk • communicates changes relevant to the EP to the Production Environment team.
Operations Supervisor/Operations Team Leader/Maintenance Team Leader/ Shift Supervisor	• accountable for the day-to-day operations of the facility including effective shift handover; completion and logging of operator routine • responsible for operations shift compliance to all legislative and regulatory requirements as defined in the EP • responsible for permitting and isolation for all frontline work activities • responsible for following emergency response protocols in accordance with the emergency response procedure and fulfilling allocated emergency response roles • responsible for leading and coordinating a multi-disciplined team performing specific duties required to support the facility, including helicopter operations, vessel movements and consumable controls.
Health, Safety and Environment Coordinator (HSEC)	• liaise with managers/supervisors on day to day management of environmental risks and issues • assist in the ongoing promotion of environmental performance at the facilities and day-to-day management HSE risks and issues • support operational personnel to understand the EP requirements applicable to their role • identify opportunities for continuous improvement and communicate these to the OIM and Environment Team • implement environmental improvement plans • communicate environmental performance information and training material to offshore personnel and maintain associated records.
Vessel-based Personnel	
Vessel Master of Facility (from point of structural disconnection from the RTM).	• understand and manage HSE aspects of the vessel, including environmental requirements • communicate with OIM as required regarding potential environmental risks applicable to vessel activities • ensure vessel meets quarantine requirements • notify AMSA and other authorities of any maritime incidents as per maritime requirements • provide, as requested by Woodside, copies of documents, records, reports and certifications (i.e. fuel use, ballast exchanges, waste logs, etc.) in a timely manner to assist in compliance reporting • ensure the vessel's Emergency Response Team have sufficient training to implement the vessel's Ship Oil Pollution Emergency Plan (SOPEP) • ensure all emergency and SOPEP drills are conducted • ensure that vessel procedures are followed in the event of an emergency or spill • immediately notify the Woodside Representative of any environmental incidents.

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Title (role)	Responsibilities related to EP
Vessel Master of Support Vessel (Subsea Support Vessels)	• understand and manage HSE aspects of the vessel, including environmental requirements • communicate with OIM as required regarding potential environmental risks applicable to vessel activities • ensure vessel meets quarantine requirements • notify AMSA and other authorities of any incidents as per maritime requirements • provide, as requested by Woodside, copies of documents, records, reports and certifications (i.e. fuel use, ballast exchanges, waste logs, etc.) in a timely manner to assist in compliance reporting • ensure the vessel's Emergency Response Team have sufficient training to implement the vessel's SOPEP • ensure all emergency and SOPEP drills are conducted • ensure that vessel procedures are followed in the event of an emergency or spill • immediately notify the Woodside Representative of any environmental incidents.
Subsea and Pipelines Site Woodside Representative	• ensure relevant management measures in this EP are implemented on the Subsea Support Vessel • ensure periodic environmental inspections are completed • ensure environmental incidents or breaches of EPOs, EPSs or MCs are reported in accordance with Woodside and regulatory requirements • ensure Subsea Support Vessel induction attendance is recorded.

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7.4 Training and Competency

As required by Regulation 14(5), this section of the implementation strategy includes measures that ensure all personnel associated with operating the Okha facility are aware of their EP related responsibilities, and that all relevant personnel have appropriate competencies and training.

Environmental training is undertaken to ensure employees and contractors whose work may impact on the environment have the necessary awareness, knowledge and competence appropriate for their role.

Different levels of training are undertaken in relation to managing environmental risks and impacts for the production offshore facilities and associated Subsea Support Vessel based IMMR activities, as follows:

- inductions for offshore facility workers and visitors
- production division competency framework training
- permit to work training (ISSoW)
- production environmental leadership training and environment awareness training
- emergency and hydrocarbon spill response training
- inductions for subsea IMMR (vessel based) personnel.

Records for Woodside production personnel, in relation to the above listed training, are maintained in Woodside's learning management system. Contractor training records are also maintained.

Competence of operations personnel can be reviewed via online dashboards.

7.4.1 Inductions for Offshore Facility Workers and Visitors

A comprehensive induction process is in place for personnel working on or visiting Woodside's offshore production facilities. The induction process is designed to equip personnel with the HSE awareness and skills necessary for them to manage their own safety and environmental performance and contribute to others working around them. The induction process includes:

- **Common Production Induction** – All employees and contractors who have not accessed a production facility within twelve months are required to undertake this induction prior to mobilisation. It includes Woodside's values, HSEQ and Process Safety, continuous improvement, risk management and ISSoW.
- **Facility Specific Induction** – All employees and contractors that have not accessed the production facility within six months are required to undertake this induction on arrival at the facility. This induction covers the HSE and emergency response issues specific to each facility. For environment, this induction covers the Facility EP, prevention of spills, waste management, fauna interactions, hazard identification and risk assessment, and incident reporting.
- **Production Offshore Environmental Leadership Training** – Key operations leadership roles (as specified within the Production Division Competency Framework Manual) are required to complete this competency on commencement of the new role and three yearly thereafter. The training covers Woodside's policies and standards, environmental legislative requirements, the EP, key environmental risk and impacts, environmental reporting, environmental management tools (e.g. improvement planning, compliance reviews and audits), hydrocarbon spill response and environmental accountabilities.

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- **Production Offshore Environmental Awareness Training** – All new offshore operational personnel are required to undertake this online training on commencement of the new role and two yearly thereafter. This training covers environmental legislative requirements, the facility EP, key environmental hazards and control measures (including waste management, spill prevention, chemical storage, wildlife interactions), environmental management tools, hazard and incident reporting, spill response, and environmental responsibilities.

7.4.2 Production Division Competency Framework Training

The production division competency framework manual defines a framework to make sure all personnel on operating facilities are competent to perform their work and that competency is managed. By doing this, the potential for unplanned (accident/incident) type events that could result in environmental impact is minimised.

Operational Area Licence to Operate (LTO) roles are those roles related to oil and gas processing, equipment maintenance, marine regulations, emergency response and any other roles involved with safeguarding the facility integrity, including all roles where high-risk work licences are required. Additionally, roles mandated by Woodside such as HSEC and helicopter landing officer are included in the LTO roles process.

The requisite competency and training for each LTO role has been defined. Competencies for these LTO roles are stipulated by the governance group for each respective position and are based on the relevant Australian or International standards which apply. In cases where no Australian or International standards are available or applicable, training is based on the relevant Woodside Standard as determined by the respective governance group.

Contractors working on Woodside facilities are required to verify the competency of their personnel through the contractor's own verification systems. Additionally, contractor personnel working on Woodside facilities are required to be registered in Woodside's Contractor Verification Service (CVS) beforehand. Personnel registered in CVS have had their skills and qualifications independently verified on behalf of Woodside thereby confirming that contractor personnel hold the required competencies before mobilisation to the facility.

The LTO Roles Report (available online on the Woodside Competency Reporting Dashboard on the Production Academy Intranet page) provides the conformance status of the facility against the LTO roles requirements.

7.4.3 Permit to Work System Training

The ISSoW permit to work system (see Section 7.1.1) is a key element in ensuring that all necessary steps are taken to ensure the safety of personnel, protection of the environment and technical integrity of the facility. The ISSoW system takes a risk-based approach to all activities, thus tasks with higher levels of risk are subjected to greater scrutiny and control.

All members of the workforce that are required to work with ISSoW (Section 7.1.1) receive training commensurate with the level of authority and responsibility they hold in ISSoW.

7.4.4 Emergency and Hydrocarbon Spill Response Training

All operations personnel involved in crisis and emergency management are required to commit to ongoing training, process improvement and participation in emergency and crisis response (both real and simulated), including emergency drills specific to potential incidents at the Okha facility. Training includes task specific training and role based training and 'on the job' experience (i.e. participation in crisis or emergency management exercises). Roles based training is further described in Section 7.8.

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An overview of Woodside's hydrocarbon spill response training and competency requirements are provided in dashboards for key responder roles. The roles are consistent with Woodside's crisis and emergency management incident control structure.

Woodside Hydrocarbon Spill Preparedness Advisor(s) are responsible for maintaining hydrocarbon spill preparedness competency. This includes the identification and development of approved competency and non-competency based courses, identification of relevant personnel required to undertake training and ensuring training records are maintained. Minimum Woodside capabilities will continue to be identified and documented.

7.4.5 Subsea IMMR Activity Environmental Awareness

At the beginning of, and during a new Subsea IMMR activity, the Subsea Support Vessel crew including contractor crew, Woodside representatives and other relevant personnel are required to undertake a vessel induction before commencing work. This induction covers HSE requirements for the vessel and IMMR activities, and as required environmental information specific to the activity location. The induction may cover the following environmental information:

- adherence to standards and procedures, and the use of Job Safety Analysis and permit to work hazard identification and management process
- spill management including prevention, response and clean-up, location of spill kits and reporting requirements
- waste management requirements and location of bins
- reporting of marine fauna, location of forms and charts
- chemical management requirements.

All personnel who undertake the project induction are required to sign an attendance sheet which is retained.

Regular HSE meetings are held on Subsea Support Vessels with crew. During these meetings, any environmental incidents are reviewed, and environmental awareness material presented.

7.5 Monitoring, Auditing, Management of Non-conformance and Review

Regulation 14(6) states that the implementation strategy is to provide for the monitoring, audit, management of non-conformance and review of operator's environmental performance and the implementation strategy itself.

This Section of the EP outlines the measures undertaken by Woodside to regularly monitor the management of environmental risks and impacts of the Okha facility against the EPOs, EPSs and MCs, with a view to continuous improvement of environmental performance. The effectiveness of the implementation strategy is also reviewed periodically as part of the monitoring and assurance process.

7.5.1 Monitoring

Woodside and its Contractors will undertake a program of periodic monitoring during the Petroleum Activities Program. This information will be collected using the tools and systems outlined below based on the EPOs, controls, EPSs and MCs in this EP. Environmental aspects are integrated into Woodside-wide functional and asset review and assurance processes, which deliver effective governance. This integration of environmental controls into appropriate parent systems and processes includes process safety management (Section 7.1.2),

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contractor management (Section 7.1.3), marine assurance (Section 7.5.2.4), and energy efficiency optimisation (e.g. Section 3.6.8.6 – Power Generation), and provides multi-faceted assurance of routine implementation.

The tools and systems will collect, as a minimum, the data (evidence) referred to in the MCs in Sections 6.6 and 6.6.8. The collection of this data will form part of the record of compliance maintained by Woodside and will form the basis for demonstrating that the EPOs and EPSs are met. Compliance will be summarised in a series of routine reporting documents (refer to Section 7.7.3).

The following tools and systems to monitor environmental performance, (including collection of evidence of compliance with controls), where relevant, will include:

- environmental emissions/discharge reporting systems that record volumes of planned discharges to ocean and atmosphere, e.g. via the Production Allocation System and process historian database – a summary of emissions and discharges monitoring that will be undertaken during the Petroleum Activities Program is provided within Table 7-3
- monitoring of progress against the Production Function scorecard for KPIs (Section 7.5.4.2)
- routine internal reporting (as described in Section 7.7.2) and routine external annual compliance reporting (as described in Section 7.7.3)
- internal auditing and assurance program (as described in Section 7.5.2).

Collectively, these systems/tools involve collection of evidence of compliance with controls. Throughout the Petroleum Activities Program, Woodside will continue to identify any new source-based risks and impacts through the Monitoring and Auditing systems and tools described above and within Section 7.5.

Other examples of assurance tasks implemented through the EP include (as an example);

- start of shift operator walk arounds
- permit to work hazard, risk management check list, area sign-on, and permit audits (ISSoW – Section 7.4.3)
- technical integrity SCE performance reviews (daily, weekly, monthly) (Section 2.7.5)
- ongoing maintenance performance assurance (e.g. conformance dashboard)
- management system performance audits reviews (e.g. MSPSs) (Section 7.5.2)
- data gathering and governance dashboard presentations (e.g. training conformance).

7.5.1.1 Receptor-Based Knowledge Updates

Under the Woodside Environmental Knowledge Management System regular monitoring to maintain currency of receptor knowledge is carried out as follows:

- Quarterly review of DoEE EPBC Act listed species status, listed species Recovery/Management and Conservation plans is completed and recorded by Environment Science team. The outcome of every monthly review is summarised and issued to the relevant Environment personnel responsible for EP implementation for their consideration.
- Under the Oil Spill Scientific Monitoring Programme preparedness, an annual review and update to the environmental baseline studies database is completed and documented.

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- Periodic location focussed environmental studies baseline data gap analyses are completed and documented. Any subsequent studies scoped and executed as a result of such gap analysis are managed by the Environment Science Team and tracked via the Corporate Environment Baseline Database.

7.5.1.2 Management of Newly Identified Impacts and Risks

New sources of receptor based impacts and risks identified through monitoring and auditing systems and tools and the Woodside Environment Knowledge Management System will be assessed using the Change Management Process (Section 7.1.4).

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Table 7-3: Summary of emissions and discharges monitoring for the Petroleum Activities Program

Category	Parameter to be Monitored/Reported	Monitoring Frequency	Monitoring Equipment/Methodology	EP Reference
Planned Emissions				
Atmospheric Emissions from fuel combustion	Greenhouse, energy and criteria pollutants	Normally continuous process metering/annual reporting	NGERS and NPI reporting estimation methods (e.g. fuel/flare flow meters, throughput meters, process estimation)	Section 6.6.7
	Fuel gas and flare intensity	Normally continuous process metering/monthly reviews	Fuel and flare flowmeters inform intensity profiles – tracked against optimisation targets	Section 6.6.7
Planned Discharges				
Discharge of subsea control fluids during well actuations	Subsea control fluid consumption	Normally continuous process indication/monthly review	Subsea control fluid consumption surveillance. Process indication for gross leaks/ruptures	Section 6.6.4
Discharge of hydrocarbons and chemicals during subsea IMMR activities	Volumes of hydrocarbons and chemicals released subsea	As required, during IMMR activities (activity specific)	Estimates based on known volumes pumped and ROV observation	Section 6.6.4
Discharge of cooling water	Volume of cooling water discharged	Continuously	Flow meter measuring discharged volume	Section 6.6.5
Waste recycling and disposal	Quantities of solid and liquid wastes disposed of onshore	Ongoing	Facility waste manifest	Section 6.7.2
Unplanned Emissions and Discharges				
Unplanned emissions and discharges	Nature of release	As required	HSEQ Event Reporting System (First Priority)	Sections 6.8.2 to 6.8.9

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7.5.2 Auditing

7.5.2.1 Operations Assurance

To provide confidence, based on evidence commensurate with risk, that business objectives are met, business activities are performed and risks are managed, assurance is performed as described in the Provide Assurance Procedure and the Provide Assurance Guideline. The Guideline aims to explain how the Operations Division Assurance Team implement WMS Assurance requirements, while concurrently satisfying the Operations Division's specific objectives.

Operations Assurance Assignments are contained within the Operations Division Integrated Assurance Assignment Plan.

Environmental assurance activities are conducted on a regular basis to help:

- verify environmental risks and potential impacts are being managed in accordance with the EPOs and EPSs detailed in this EP
- monitor, review and evaluate the effectiveness of the performance outcomes and standards detailed in this EP
- verify effectiveness of the EP implementation strategy
- identify potential non-conformances.

The outputs of the assurance process are corrective actions that feed the improvement process. Therefore, assurance is a key driver of continuous improvement.

7.5.2.2 Annual Offshore Inspection

An inspection of the Okha facility is undertaken every calendar year by the Production Environment Team. Selected risk areas/activities are inspected to review environmental performance against the EPOs and EPSs and verify that control measures are effective in reducing the environmental risks and impacts of the activity to an ALARP and acceptable level.

The inspection also includes review of conformance with selected aspects of the EP implementation strategy. All risk sources/activities applicable to the offshore facility will be reviewed over a three-year rolling period. Records of findings and close-out of any corrective or improvement actions are maintained (close-out is tracked in Woodside's action tracking system).

7.5.2.3 Subsea Support Vessel Environment Inspection

Environmental inspections of subsea support vessels are undertaken. This involves annual and ongoing inspections of subsea support vessels to ensure that any subsea support vessel is compliant with both the EP and the approved Contractor Management system. Inspections are conducted in line with the SSPL contractor implementation package, however, may include additional requirements for project specific inspection items.

Vessel Inspection findings are captured within a closeout report. Actions arising from subsea support vessel environmental audits are added to the relevant Environmental Commitments and Actions Register (eCAR) within the Subsea Construction, Inspection, Maintenance, Monitoring and Repair Environment Project Register. This eCAR is used to track support vessel compliance with EP commitments, including any findings and corrective actions.

7.5.2.4 Marine Assurance

Marine assurance is undertaken in accordance with Woodside marine assurance procedures which defines the marine assurance activity practices for the different types of vessels either chartered

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directly by or on behalf of Woodside (including support vessels and offtake tankers). The marine assurance process is managed by the Marine Assurance Team of the Marine Services Group.

The processes and procedures used are based on industry standards and consideration of guidelines and recommendations from recognised industry organisations such as Oil Companies International Marine Forum (OCIMF) and International Maritime Contractors Association.

Support Vessel Assurance

Under the Offshore Vessel Suitability Procedure and the Offshore Vessel Assurance Procedure support vessels (facility and subsea) are subject to a pre-charter vessel suitability and marine assurance process. Intent of the offshore vessel suitability process is to ensure any offshore vessel (i.e. support vessel) is capable of the defined work scope. Intent of the offshore vessel marine assurance process is to ensure all marine contractors and associated suitable vessels are compliant with regard to all legislative and statutory requirements, are well managed and well maintained in addition to meeting any specific requirements held by Woodside.

Under the offshore vessel assurance procedures, regular Woodside, or third-party inspections are usually required for support vessels. Support vessel inspections are not always required and may be replaced by a risk assessment. Woodside uses the OCIMF Offshore Vessel Inspection Database inspection as its primary means for inspecting vessels. These inspections assess compliance with laws of the international shipping industry, including safety management requirements and maritime legislation including International Convention of the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL) and other International Maritime Organisation Standards.

Offtake Vessel Assurance

Prior to gaining Woodside's acceptance for offtake from the Okha FPSO, under tanker assurance procedures and offtake tanker FPSO compatibility procedures, export tankers are subject to a marine assurance process and a vessel compatibility process. Under these procedures, export tankers are assessed for their performance, quality (historic performance or incidents, documentation, systems and procedures) and operational compatibility with the facility. Additional quality assurance of tankers is provided by external bodies with access to extensive databases, which ensures thorough evaluation (for example, the Shell 'GMAS' system). A tanker will only be accepted by Woodside for offtake if it passes the assessment process. This requirement applies to each tanker offload irrespective of the tanker flag, operator, or the date of the last visit to a Woodside terminal. The export tanker assurance process is documented. Tanker assurance records are retained by Woodside.

Once accepted for offtake, the tanker must comply with requirements under the Okha Terminal Handbook, which contains rules, information and operations guidelines. The Handbook also describes the operations and approach to the Okha facility's cautionary and safety zone and the rules that apply in each area. Approach to the facility must first be approved by the Okha OIM and then occurs under supervision of a Woodside Pilot, in accordance with the International Maritime Organization and International Maritime Pilots Association Guidelines.

Environmental requirements specific to offshore facility support vessel contractors are communicated via Woodside marine charterers instructions. This document provides the Master of a vessel on hire to Woodside, with a clearly defined set of requirements and procedures for operating the vessel in the vicinity of the Woodside's operating facilities. This includes the management of environmental risks and impacts from the Okha facility. The document includes information on:

- applicable legislation and guidelines
- roles and responsibilities
- marine fauna interaction guidance

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- incident reporting requirements.

Environmental requirements specific to Subsea Support Vessels are communicated via the Subsea Environmental Compliance Package. This document outlines mandatory environmental management requirements for Subsea Support Vessels and associated contractors.

7.5.3 Management of Non-conformance (Internal)

Woodside employees and Contractors are required to internally report all environmental incidents and hazards, including potential non-conformances with EPOs and EPSs in this EP.

The Health, Safety and Environment Event Reporting and Investigation Procedure defines how incidents and hazards are internally reported. Key requirements are set out through the use of an Event Report Form, which includes details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence. An internal online database called First Priority is used for the recording and reporting of these events. Corrective actions are monitored using First Priority and closed out in a timely manner.

Detailed investigations are completed for all incidents with an actual impact of A, B or C, and high potential environmental incidents and hazards. The classification, reporting, investigation and actioning of environmental incidents and hazards is undertaken in accordance with the Health, Safety and Environment Event Reporting and Investigation Procedure supported by the HSE Event Reporting Guideline. Event bulletins may be used for communication of learnings from significant events.

Non-conformances with EPOs and EPSs are also internally reported and investigated in accordance with Regulatory Compliance Management Procedure, supported by the Regulatory Compliance Management Guideline.

External regulatory reporting requirements for this activity are outlined in Section 7.7 of this EP.

7.5.4 Review

7.5.4.1 Environmental Risk Review

Woodside risk management processes include risk review. Woodside's risk management processes are described in Sections 2.2.1 and 7.1.3 and are applied on a day-to-day basis. The Facility Environmental Impacts and Risk Register must be reviewed and updated every five years.

Monitoring (Section 7.5.1) and assurance (Section 7.5.2) and review (Section 7.5.4) are also used to identify potential new information that may arise during the activity and ensure that performance outcomes and standards are being met and EP environmental control measures are effective. Whilst conducting these activities, qualified, experienced environment advisors, in consultation with experienced Operational and/or Engineering personnel use their professional judgement, to identify potential new control measures that have potential to improve environmental outcomes or reduce risk. As various monitoring/assurance/review processes are used there is not an overarching procedure/checklist that is suitable to contain a prompt for consideration of new environmental controls.

In addition, Woodside's risk management practices and processes are systematically applied on an ongoing basis to activities provided for within the EP (as summarised within Section 7.1.3). Via these processes and practices, new risk controls for individual planned and unplanned events may be selected and implemented (proportional to risk levels). When such risk controls are identified by environmental advisors as being relevant to the overarching EP sources of risk, these may also be added as new EP control measures. Any new or improved EP environmental controls or specific measures (that have the potential to improve environmental outcomes or reduce risk), can be tracked within the production EP updates register for incorporation into the EP at its next revision. The EP may be internally revised to reflect these changes without resubmission.

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Where review processes identify new or improved controls relevant to environmental risks identified in this EP (that have the potential to improve environmental outcomes or reduce risk), the EP may be internally revised to reflect these changes without resubmission.

7.5.4.2 KPI Review

Within the Production Division environment, key performance indicators (KPIs) are developed annually and agreed with senior management (i.e. Okha Asset Manager). Progress against the environment KPIs is tracked within Asset Scorecards.

Reviews of hydrocarbon spill arrangements and testing are carried out in accordance with Appendix D.

7.5.4.3 Learning and Knowledge Sharing

Learning and knowledge sharing occurs within the Production Division via a number of different methods, including for example:

- Operations Learnings meetings
- event investigations
- event bulletins
- engineering and technical authorities discipline communications and sharing.

7.5.4.4 Continuous Improvement

Continuous Improvement (CI) Projects to improve production or environmental performance that involve refurbishment, modification or major maintenance on the facility are typically managed by Brownfields Engineering, and required to follow appraise and develop management procedures. Currently, the Procedure requires that all projects be managed in accordance with the Opportunity Management Framework which supports the progressive maturation of an opportunity through value creation in the Assess and Select Phases and the maintenance of value in the Develop and Execute phases.

To support the accountable executive to make a decision on whether a CI Project should proceed to the next phase in the Opportunity Management Framework, it is sometimes necessary to conduct a trial of the modification to determine the outcomes that can be expected if the modification is implemented. Due to prioritisation of resources, the phased progress of opportunities, competition between different solutions and long-term strategic and financial considerations, it is not possible to set quantitative success criteria to determine whether a modification will be implemented based on the results of trials. Instead, the results of a trial are used to inform a decision on whether to progress the CI Project to the next phase in the Opportunity Management Framework. Decisions are typically made with two key considerations; whether the business is ready to proceed which has a technical/functional focus and whether there is a business case for progressing to the next phase. The business case may consider the ALARP position for the CI Project, if relevant.

7.6 Record Keeping

Compliance records (outlined in MCs in Section 6) will be maintained. Record keeping will be in accordance with Regulation 14(7) that addresses maintaining records of emissions and discharges such that the records can be used to assess whether EPOs and EPSs are being met (refer to Section 7.5.1 and Table 7-7 for a summary of records that will retained).

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7.7 Reporting

7.7.1 Overview

In order to meet the EPOs and EPSs outlined in this EP, Woodside undertakes reporting at a number of levels. These reporting arrangements are outlined below.

7.7.2 Routine Reporting (Internal)

7.7.2.1 Daily Reports

The following daily reports, containing environmental performance information are issued:

- Pan-Woodside Daily Production Report – The report includes facility performance information on production and a log of any HSE events.
- Subsea support vessel Daily Progress Report(s) – During subsea IMMR activities, daily reports are issued by the Woodside Site Representative. The reports provide performance information on HSE events, diesel use, together with equipment information, current and planned work activities.

7.7.2.2 Performance Reporting

A number of routine performance reports are developed in support of the facility operational activities. These reports cover HSE, production and process safety performance. Information included in these reports, relevant to the EP, includes:

- summary of environment incidents
- current and planned work activities, significant events (e.g. shutdowns, failures)
- integrity status and process safety metrics
- status of subsea IMMR activities.

7.7.3 Routine Reporting (External)

7.7.3.1 Environmental Performance Review and Reporting

In accordance with applicable environmental legislation for the activity, Woodside is required to report information on environmental performance to the appropriate regulator.

Routine regulatory reporting requirements are summarised in Table 7-4. The requirements include that Woodside will develop and submit an annual Environmental Performance Report to NOPSEMA, with the first report submitted within 12 months of the commencement of activities covered by this EP (as per the requirements of Regulation 14(2)(b)) (i.e. by 30 April the following year).

Table 7-4: Routine external reporting requirements

Report	Recipient	Frequency	Content
Monthly Recordable Incident Report	NOPSEMA	Monthly, by 15 of each month	As required by Regulation 26B, details of recordable incidents that have occurred under the EP for the previous month. Refer to Section 7.7.5 for more detail.
Annual Environment Plan Performance Report	NOPSEMA	Annual, by 30 April of the year following reporting period	As required by Regulation 14 (2) and 26C the report will report compliance with the EPOs and EPSs outlined in Section 6 of this EP. The reporting period is 1 January to 31 December each year.

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Report	Recipient	Frequency	Content
National Pollutant Inventory (NPI) Report	DoEE	Annual, by 30 September each year	Summary of the emissions to land, air and water including those from the facility. Reporting period 1 July to 30 June each year.
National Greenhouse and Energy Reporting (NGERS)	Clean Energy Regulator	Annual, by 31 October each year	Summary of energy use and greenhouse gas emissions including those from the facility. Reporting period is 1 July to 30 June each year.

7.7.3.2 End of the Petroleum Activities Program Notification

In accordance with Regulation 29, Woodside will notify NOPSEMA[26] within ten days of the completion of the Petroleum Activities Program. The Petroleum Activities Program is not expected to end within the five-year life of this EP.

7.7.3.3 End of the Environment Plan

The EP will end when Woodside notifies NOPSEMA that the Petroleum Activities Program has ended, all of the obligations identified in this EP have been completed, and NOPSEMA has accepted the notification, in accordance with Regulation 25A of the Environment Regulations. As noted above, the Petroleum Activities Program is not expected to end within the five-year life of this EP.

7.7.4 Incident Reporting (Internal)

All Woodside employees and contractors are required to report environmental incidents and non-conformances with this EP. Incidents are reported using an Event Report Form which includes details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence (for further details refer to Section 7.5.3).

7.7.5 Incident Reporting (External) – Reportable and Recordable

Woodside's regulatory reporting requirements are outlined within the Regulator Event Reporting Procedure supported by the Regulator Event Reporting Guideline.

7.7.5.1 Reportable Incidents

A reportable incident is defined under Regulation 4 of the Environment Regulations as 'an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage'.

A reportable incident for the Petroleum Activities Program is:

- An incident that has caused environmental damage with a Consequence Level of Moderate CAN or above (as defined under Woodside's Risk Table; refer to Section 2.6).
- An incident that has the potential to cause environmental damage with a Consequence Level of Moderate CAN or above (as defined under Woodside's Risk Table – refer to Section 2.6).

The environmental risk assessment (Section 6) for the Petroleum Activities Program identifies those risks with a potential consequence level of C+ for environment. The incidents that have the potential to cause this level of impact include hydrocarbon loss of containment events to ocean resulting from either:

- loss of well containment (MEE-01)
- subsea equipment loss of containment (MEE-02)

[26] NOPSEMA has already been notified of commencement of operations of the facility.

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- topsides loss of containment (MEE-03)
- offtake equipment loss of containment (MEE-04)
- loss of structural integrity (MEE-05)
- cargo tank loss of containment (MEE-06)
- loss of marine vessel separation (MEE-07)
- loss of control of suspended load from Okha lifting operations (MEE-08).

Any such incidents represent potential events which would be reportable incidents. Reporting of incidents is undertaken with consideration of NOPSEMA (2014) guidance stating, 'if in doubt, notify NOPSEMA', and assessed on a case-by-case basis to determine if they trigger a reportable incident as defined in this EP and by the regulations.

Notification

NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations. Woodside will:

- orally notify NOPSEMA of all reportable incidents to the regulator as soon as practicable, but within two hours of the incident or of its detection by Woodside
- provide a written record of the reported incident to NOPSEMA, the National Offshore Petroleum Titles Administrator (NOPTA) and the Department of the responsible State Minister (Department of Mines, Industry Regulation and Safety [DMIRS]) as soon as practicable after the oral notification of the incident
- complete a written report for all reportable incidents using a format consistent with the NOPSEMA Form FM0929 – Reportable Environment Incident which must be submitted to NOPSEMA as soon as practicable, but within three days of the incident or of its detection by Woodside
- provide a copy of the written report to NOPTA and DMIRS, within seven days of the written report being provided to NOPSEMA.

7.7.5.2 Recordable Incidents

A recordable incident is defined under Regulation 4 of the Environment Regulations as a 'breach of an EPO or EPS, in the EP that applies to the activity, that is not a reportable incident'.

Any breach of the EPOs or EPSs (as presented within Section 6) will be raised as a recordable incident and managed as per the notification and reporting requirements outlined below and internal requirements outlined in Section 7.7.

Additional performance standards and management measures are included within Section 7.9 of the implementation strategy and within stakeholder consultation (Section 6). Any breach of these will not be raised as a recordable incident (as defined within the Environment Regulations) but will be managed internally.

Notification

NOPSEMA will be notified of all recordable incidents, according to the requirements of Regulation 26B (4). Woodside will:

- provide a written record not later than 15 days after the end of the calendar month using a format consistent with the NOPSEMA Form – Recordable Environmental Incident Monthly Summary Report (Appendix E).

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7.7.5.3 Other External Reporting Requirements and Notifications

In addition to the notification and reporting of environmental incidents defined under the Environment Regulations and Woodside requirements, the following incident reporting requirements also apply in the Operational Area if the spill originates from a vessel:

- Any oil pollution incidents in Commonwealth Waters will be reported (by the vessel master) to AMSA Rescue Coordination Centre (RCC) as per Article 8 and Protocol I of MARPOL within two hours via the national emergency 24-hour notification contacts, and a written report within 24-hours of the request by AMSA. (This requirement is included in the Okha Oil Pollution First Strike Plan; Appendix H).

  If the ship is at sea, reports are to be made to:

  Free call: 1800 641 792

  Phone: 08 9430 2100 (Fremantle).

- Any spills greater than ten tonnes in Commonwealth Waters must be reported (by the vessel master) to AMSA within one hour. (This requirement is detailed in the Okha Oil Pollution First Strike Plan; Appendix H). Reports are to be made via the national 24-hour emergency notification contacts (AusSAR: RCC):

  Rescue Coordination Centre Australia (RCC Australia)

  Phone: 02 6230 6811

  Facsimile: 02 6230 6868

  Telex: 62349

  Free call: 1800 641 792

  AFTN: YSARYCYX.

- A hydrocarbon spill incident with potential to significantly impact MNES must be reported to DoEE.
- If the activity described within this EP results in the unintentional death of or injury to a fauna that constitute MNES (i.e. species listed as Threatened or Migratory under the EPBC Act), and the activity was not authorised by a permit, the Secretary of the DoEE should be notified within seven days of becoming aware of the results of the activity:

  The Secretary

  DoEE

  Hotline: 1800 803 772

  Email: protected.species@environment.gov.au.

For hydrocarbon spill incidents, other agencies and organisations[27] will be notified as appropriate to the nature and scale of the incident as per procedures and contact lists in the Oil Pollution Emergency Arrangements (Australia) and the Okha Oil Pollution First Strike Plan (Appendix H), including but not limited to:

- A hydrocarbon spill incident with the potential to significantly impact MNES must be reported to DoEE.

[27] The Director of National Parks will be notified if Woodside becomes aware of a hydrocarbon spill occurring within, or potentially impacting upon the values of, a Commonwealth Marine Park.

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- A hydrocarbon spill incident occurring within a marine park, or with the potential to impact a marine park must be reported to DNP as soon as possible. Notification should be provided to the 24-hour Marine Compliance Duty Officer on 0419 293 465. The notification should include:
    - titleholder details
    - time and location of the incident (including name of marine park likely to be affected)
    - proposed response arrangements as per the Oil Pollution Emergency Plan (e.g. dispersant, containment, etc.)
    - confirmation of providing access to relevant monitoring and evaluation reports when available
    - contact details for the response coordinator.

DNP notification to marineparks@environment.gov.au is required:

- When the EP is approved by NOPSEMA.
- Notification at least 10-days prior to all inspection, monitoring (including scientific monitoring), maintenance or repair activities occurring within the Montebello AMP (excluding transiting) and conclusion of that activity.
- In cases where inspections are required for emergent issues or following a cyclone, notifications will be provided as soon as practicable. Notification information should be consistent with the Petroleum activities and AMP guidance note.

7.8 Emergency Preparedness and Response

7.8.1 Overview

Under Regulation 14(8), the implementation strategy must contain an oil pollution emergency plan (OPEP) and provide for the updating of the OPEP. Regulation 14(8AA) outlines the requirements for the OPEP which must include adequate arrangements for responding to and monitoring of oil pollution.

A summary of how this EP and supporting documents address the various requirements of Environment Regulations relating to oil pollution response arrangements is shown in Table 7-5.

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Table 7-5: Oil pollution preparedness and response overview

Content	Environment Regulations Reference	Document/Section Reference
Details (oil pollution response) control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level	Regulation 13 (5), (6), 14 (3)	Oil Spill Preparedness and Response Mitigation Assessment (Appendix D).
Describes the oil pollution emergency plan	Regulation 14 (8)	Environment Plan: Section 7.8. Woodside's oil pollution emergency plan has the following components: • Oil Pollution Emergency Arrangements (Australia) • Okha Oil Pollution First Strike Plan (Appendix H) • Oil Spill Preparedness and Response Mitigation Assessment (Appendix D).
Details the arrangements for responding to and monitoring oil pollution (to inform response activities), including control measures	Regulation 14 (8AA)	Oil Spill Preparedness and Response Mitigation Assessment (Appendix D). Okha Oil Pollution First Strike Plan (Appendix H).
Details the arrangements for updating and testing the oil pollution response arrangements	Regulation 14 (8), (8A), (8B), (8C)	Environment Plan: Section 7.8.6. Oil Spill Preparedness and Response Mitigation Assessment (Appendix D).
Details provisions for monitoring impacts to the environment from oil pollution and response activities	Regulation 14 (8D)	Oil Spill Preparedness and Response Mitigation Assessment (Appendix D).
Demonstrates that the oil pollution response arrangements are consistent with the national system for oil pollution preparedness and control	Regulation 14 (8E)	Oil Pollution Emergency Arrangements (Australia).

7.8.2 Emergency Response Preparation

The Corporate Incident Communication Centre (CICC), based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency. The CICC is staffed by an appropriately skilled team available on call 24-hours a day. The purpose of the team is to coordinate rescues, minimise damage to the environment and facilities, and to liaise with external agencies. A description of Woodside's Incident Command Structure and arrangements is further detailed in the Woodside OPEA (Australia). Roles and responsibilities for facility emergency response are outlined in the Okha Safety Case and the Pipelines Safety Case are consistent with the Okha Emergency Response Plan and the Pipelines Emergency Response Plan.

Woodside has a number of Emergency Response Plans (ERP) in place, which detail the actions and resources available in the event of various emergency scenarios. Electronic copies of the ERPs are available on the facility Virtual Bookshelves. Hard controlled copies are available on the facilities.

In addition, the Emergency Preparedness MSPS (M06) is in place to assure that in the event of an incident, the organisation is appropriately prepared for all necessary actions which may be required for the protection of People, Environment, Asset, Reputation and Livelihood.

7.8.2.1 Initial Response to Facility Incident

The facility is equipped with emergency shutdown systems designed to protect personnel, the facility and the environment from unsafe operating conditions and catastrophic situations.

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Emergency shutdown systems are provided as a means of isolation in response to process upsets and facility conditions (including associated flowlines and risers) that could result in loss of hydrocarbon inventories, or to reduce the potential impact from a hydrocarbon loss of containment event on the facility. Provision has been made for process and facility alarm systems to provide early indication of any process upset conditions and potential hazardous events, including fire and gas alarms.

The key ERP relevant to the facility and subsea infrastructure (excluding the export pipeline) is the Okha Emergency Response Plan. This plan covers health, safety, asset and environmental risks (including fire, structural integrity, sabotage, etc.) to ensure the range of occupational, asset and environmental risk exposures from incidents have been considered and plans are in place for their management. The plan provides specific details on the initial response required during events with potential significant environmental consequences such as a hydrocarbon spill, subsea hydrocarbon leak or potential collision.

The Pipelines Emergency Response Plan covers key ERP relevant to the export pipeline, as well as other major pipelines on Woodside's NWS facilities.

7.8.3 Oil and Other Hazardous Materials Spill

A significant hydrocarbon spill during the Petroleum Activities Program is unlikely, but should such an event occur, it has the potential to cause serious environmental and reputational damage if not managed properly. The Woodside OPEA (Australia) document, supported by the Okha Oil Pollution First Strike Plan which provides tactical response guidance to the activity/area (Appendix H), and Appendix D of this EP, cover spill response for this Petroleum Activities Program.

In accordance with Woodside's Hydrocarbon Spill Preparedness and Response Procedure, the Hydrocarbon Spill Preparedness Manager is responsible for the management of Woodside's hydrocarbon spill response equipment, and for the maintenance of hydrocarbon spill preparedness and response documentation. In the event of a major spill, Woodside will request that AMSA (administrator of the National Plan) provides support to Woodside through advice and access to equipment, people and liaison. The interface and responsibilities, as defined under the National Plan, are described in the OPEA (Australia). AMSA and Woodside have a Memorandum of Understanding in place to support Woodside in the event of a hydrocarbon spill.

The Okha Oil Pollution First Strike Plan provides immediate actions required to commence a response.

Vessels will have 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 Okha Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs, if hydrocarbons are released to the marine environment from a vessel.

Woodside has established EPOs, EPSs and MCs to be used for hydrocarbon spill response during the Petroleum Activities Program, as detailed in Appendix D.

7.8.4 Emergency and Spill Response

Woodside categorises incidents in relation to response requirements as follows:

- **Level 1 Incident** – Level 1 incidents are those that can be resolved through the use of existing resources, equipment and personnel. A Level 1 incident is contained, controlled and resolved by site / regionally based teams using existing resources and functional support services.
- **Level 2 Incident** – Level 2 incidents are characterised by a response that requires external operational support to manage the incident. It is triggered in the event the capabilities of the

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tactical level response are exceeded. This support is provided to the activity via the activation of all, or part of, the responsible ICC.

- **Level 3 Incident** – A Level 3 incident or crisis is identified as a critical event that seriously threatens the organisation's People, the Environment, company Assets, Reputation, Livelihood or essential Services. At Woodside, the Crisis Management Team (CMT) manages the strategic impacts in order to respond to and recover from the threat to the company (material impacts, litigation, legal & commercial, reputation etc.). The ICC may also be activated as required to manage the operational response to the Level 3 Incident.

7.8.5 Emergency and Spill Response Drills and Exercises

Testing of Woodside's capability to respond to incidents will be conducted in alignment with the Emergency and Crisis Management Procedure. The frequency of these tests will be conducted as prescribed in Section 7.8.6. The company emergency response testing regime is aligned to existing or developing risks associated with Woodside's operations and activities. Corporate hazards/risks outlined in the corporate risk register, respective Safety Cases or project Risk Registers, are the key reference point for EM and CM exercise development. External participants may be invited to attend crisis exercises and may include government agencies, specialist service providers, oil spill response organisations or industry members with which we have mutual aid arrangements.

The objective is to exercise procedures, skills and teamwork of the Emergency Response and Command Teams in their ability to respond to MAEs and MEEs. After each exercise, the team holds a debrief session, during which the exercise is reviewed. Any lessons learnt or areas for improvement are identified and incorporated into emergency procedures where appropriate.

Table 7-6: Testing of response capability to incidents

	Response Testing
Level 1 Response	One Level 1 drill to be conducted per week, during the activity.
	Two Level 1 oil spill response drills to be conducted per year. These drills should test elements of the recommended response identified in the Okha Oil Pollution First Strike Plan in relation to the level of the incident (Appendix H). Note, facilities undertake Level 1 exercises regularly (generally one per swing).
Level 2 Response	Minimum one Emergency Management exercise biennially.
Level 3 Response	The number of CMT exercises conducted each year is determined by the Chief Executive Officer, in consultation with the General Manager of Security and Emergency Management.

7.8.6 Testing of Hydrocarbon Spill Response Arrangements

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 is adequately tested, the Hydrocarbon Spill Preparedness Capability Development Team ensures tests are conducted in alignment with the Hydrocarbon Spill Arrangements Testing Schedule.

Woodside's Hydrocarbon Spill Preparedness & Response Testing Schedule aligns with international good practice for spill preparedness and response management; the testing is compatible with the IPIECA Good Practice Guide and the Australian Emergency Management Institute Handbook.

The schedule identifies the type of test which will be conducted annually for each arrangement, and how this type will vary over a five-year rolling schedule. Testing methods may include (but are not limited to) audits, drills, field exercises, functional workshops, assurance reporting, assurance monitoring and reviews of key external dependencies.

Activity specific Oil Spill Pollution First Strike Plans are developed to meet the response needs of that particular activity's worst credible spill scenario (Appendix H). The ability to implement these plans may rely on specific arrangements or those common to other Woodside activities. Regardless

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of their commonality, each arrangement will be tested in at least one of the methods annually. The activity specific Okha Oil Pollution First Strike Plan will be tested in alignment with Table 7-6. This ensures personnel are familiar with spill response procedures, reporting requirements and roles/responsibilities.

At the completion of testing, a report is produced to demonstrate the outcomes achieved against the tested objectives. The report will include the lessons learned, any improvement actions and a list of the participants. Alternatively, an assurance report, assurance records or audit report may be produced. These reports record findings and include any recommendations for improvement. Improvement actions and their close-out are actively recorded and managed.

7.8.7 Cyclone and Dangerous Weather Preparation

Tropical cyclones and other severe weather events are a potential risk to the safety and health of personnel and can potentially cause spills of hazardous materials into the environment from infrastructure and/or damaged vessels.

The One FPSO Cyclone Evasion Procedure sets out preparation and recovery actions to be implemented in a cyclone or potential cyclone. This Procedure will be followed in the event of a cyclone or potential cyclone and includes the option of moving the Okha FPSO off station in response to severe weather.

Subsea support vessels receive regular forecasts from the BoM. If a cyclone (or severe weather event) is forecast, the path and its development will be plotted and monitored using the BoM data. If there is the potential for the cyclone (severe weather event) to affect the Petroleum Activities Program, the vessel's Cyclone Contingency Plan will be actioned. If required, vessels can transit from the proposed track of the cyclone (severe weather event).

7.9 Implementation Strategy and Reporting Commitments Summary

Table 7-7 provides a summary of key components within the implementation strategy.

Table 7-7: Implementation strategy and reporting commitments summary

Implementation Strategy Performance Outcome (IS Pos)	Implementation Strategy Performance Standard (IS PSs)	Implementation Strategy Measurement Criteria (IS MCs)
IS PO 1 All personnel will be aware of their roles and responsibilities regarding environmental impacts and risks throughout the Petroleum Activities Program.	**IS PS 1.1** Employees and contractors visiting the facility (that have not accessed a production facility within 12 months) will undertake the Common Production Induction prior to mobilisation.	**IS MC 1.1.1** Training attendance records
	IS PS 1.2 Offshore Woodside personnel (that do not hold Environmental Leadership Training) will complete the Offshore Environmental Awareness training on commencement in the new role and two yearly thereafter.	**IS MC 1.2.1** Training attendance records
	IS PS 1.3 Key operations leadership roles will complete the Environmental Leadership Training on commencement in the new role and three yearly thereafter.	**IS MC 1.3.1** Training attendance records

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Implementation Strategy Performance Outcome (IS Pos)	Implementation Strategy Performance Standard (IS PSs)	Implementation Strategy Measurement Criteria (IS MCs)
	IS PS 1.4 EP requirements for support vessels will be communicated.	**IS MC 1.4.1** One Marine Charterers Instructions distribution records
	IS PS 1.5 EP requirements for subsea support vessels will be communicated.	**IS MC 1.5.1** Subsea Environmental Implementation Package distribution records
IS PO 2 Woodside will undertake a program of periodic monitoring during the Petroleum Activities Program.	**IS PS 2.1** This information will be collected using the tools and systems outlined in Section 7.5.1.	**IS MC 2.1.1** Monitoring reports/records
IS PO 3 Woodside will undertake environmental performance inspection and monitoring.	**IS PS 3.1** An offshore inspection will be undertaken each calendar year by the Production Environment Team to review aspects of environmental performance. All risk sources/activities applicable to the offshore facility will be reviewed over a three-year rolling period.	**IS MC 3.1.1** Records of findings available
	IS PS 3.2 Assurance related to the management of environmental risks and impacts of the facility will be completed in accordance with the Operations Division Integrated Assurance Assignment Plan.	**IS MC 3.2.1** Assurance records available
	IS PS 3.3 Environmental inspections of subsea support vessels will be undertaken annually	**IS MC 3.3.1** Records of inspections available
IS PO 4 Woodside will undertake regular reviews to monitor environmental performance.	**IS PS 4.1** Environment KPIs for the facility will be developed on an annual basis to drive continuous improvement and performance will be tracked.	**IS MC 4.1.1** KPIs and reports/scorecards tracking KPI performance available.
	IS PS 4.2 Woodside will undertake a review and submit an environmental performance report to NOPSEMA annually.	**IS MC 4.2.1** Record of submission of environmental performance reports to NOPSEMA.
IS PO 5 NOPSEMA EP reporting requirements will be met.	**IS PS 5.1** Recordable incident reports will be submitted monthly to NOPSEMA.	**IS MC 5.1.1** Report records.
	IS PS 5.2 NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations.	**IS MC 5.2.1** Record of notifications to NOPSEMA.

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Implementation Strategy Performance Outcome (IS Pos)	Implementation Strategy Performance Standard (IS PSs)	Implementation Strategy Measurement Criteria (IS MCs)
	IS PS 5.3 Woodside will notify NOPSEMA within ten days of completion of the activity (not expected to be applicable during the EP period).	**IS MC 5.3.1** Record of notification to NOPSEMA.
	IS PS 5.4 The EP will end when Woodside notifies NOPSEMA that the Petroleum Activities Program has ended, all of the obligations identified in this EP have been completed, and NOPSEMA has accepted the notification, in accordance with Regulation 25A.	**IS MC 5.4.1** Record of notification to NOPSEMA and NOPSEMA acceptance of notification.
IS PO 6 Incidents and hazards will be documented, and records maintained.	**IS PS 6.1** Details outlined in Section 6 and Section 7.7.5 are documented.	**IS MC 6.1.1** Internal records available (i.e. within First Priority).
IS PO 7 Personnel holding responsibilities in an emergency will test the arrangements supporting the activities OPEP to ensure they are effective and communicated.	**IS PS 7.1** Exercises will be conducted in alignment with the frequency identified in Table 7-6. These arrangements are conducted in accordance with Regulation 14 (8B) of the Environment Regulations: • Arrangements are tested in accordance with a schedule as per the frequency identified in Table 7-6. • Arrangements will be tested when the OPEP is significantly amended.	**IS MC 7.1.1** Spill response exercise report. Records managed in Testing of Arrangements Register.
	IS PS 7.3 Close out of actions from exercising are managed in the Testing of Arrangements Register.	**IS MC 7.3.1** Records managed in Testing of Arrangements Register.
	IS PS 8.1 Activity OPEPs will be revised at a minimum of every five years.	**IS MC 8.1.1** OPEP current and available.

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Implementation Strategy Performance Outcome (IS Pos)	Implementation Strategy Performance Standard (IS PSs)	Implementation Strategy Measurement Criteria (IS MCs)
IS PO 8 Woodside will ensure that the arrangements supporting the activities OPEP are validated.	**IS PS 9.1** Relevant documents from the OPEP will be reviewed in the following circumstances: • implementation of improved preparedness measure • a change in the availability of equipment stockpiles • a change in the availability of personnel that reduces or improves preparedness and the capacity to respond • the introduction of a new or improved technology that may be considered in a response for this activity • to incorporate, where relevant, lessons learned from exercises or events if national or state response frameworks and Woodside's integration with these frameworks changes.	**IS MC 9.1.1** The following records with be maintained: • HSPU Testing of arrangements register (Post Exercise Actions) DRIMS 10173648; • Woodside Internal Equipment Maintenance Register (DRIMS 1400051189); OPEP current and available.
IS PO 9 The OPEP will only be updated under specific circumstances to ensure the information is current.	**IS PS 10.1** • Woodside will assess potential alternatives to determine compatibility with Okha subsea control system within one year of acceptance of this EP.	**IS MC 10.1.1** • Records demonstrate a subsea control fluid compatibility study has been undertaken within one year of acceptance of this EP
IS PO 10 Woodside will pursue continuous improvement by evaluating potential alternative subsea control fluids for use on the Okha facility		

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9. LIST OF TERMS AND ACRONYMS

Acronym	Description
@	At
~	Approximately
<	Less/fewer than
>	Greater/more than
≤	Less than or equal to
≥	Greater than or equal to
°C	Degrees Celsius
24/7	24 hours a day, seven days a week
3D	Three-dimensional
ACN	Australian Company Number
ACS	Australian Customs Service
AFMA	Australian Fisheries Management Authority
AHS	Australian Hydrographic Service
AIMS	Australian Institute of Marine Science
ALARP	As low as reasonably practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines (for Fresh and Marine Water Quality)
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS/NZS	Australian Standard/New Zealand Standard
bbl	Barrel
bbl/d	Barrels per day
BDV	Blow-down Valve
BIA	Biologically Important Area
BoM	Bureau of Meteorology
BOP	Blowout Preventer
BP	Boiling Point
BTEX	Benzene, toluene, ethylbenzene, and xylene compounds
CALM	Former Western Australian Department of Conservation and Land Management (now DBCA)
CAPEX	Capital Expenditure
CCE	Common cause event
CCR	Central Control Room
CFA	Commonwealth Fisheries Association
CH_4	Methane

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Acronym	Description
CI	Continuous improvement
CICC	Corporate Incident Communication Centre
cm	Centimetre
cm^3	Cubic centimetre
CMMS	Computerised Maintenance Management System
CMT	Crisis Management Team
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COO	Chief Operations Officer
cP	Centipoise
CS	Cost Sacrifice
CV	Company Value
CVS	Contractor Verification Service
CWLH	Cossack, Wanaea, Lambert, and Hermes
D&C	Drilling and Completions
DAWR	Commonwealth Department of Agriculture and Water Resources
dB re 1 µPa	Decibels relative to one micropascal; the unit used to measure the intensity of an underwater sound
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DCS	Distributed control system
DEC	Former Western Australian Department of Environment and Conservation (now DBCA)
DEH	Former Commonwealth Department of the Environment and Heritage (now DoEE)
DEWHA	Former Commonwealth Department of the Environment, Water, Heritage and the Arts (now DoEE)
DHNRDT	Deepwater Horizon Natural Resource Damage Assessment Trustees
DIIS	Commonwealth Department of Industry, Innovation and Science
DMIRS	Western Australian Department of Mines, Industry Regulation and Safety
DNP	Director of National Parks
DoEE	Commonwealth Department of the Environment and Energy
DoT	Western Australian Department of Transport
DP	Dynamic positioning
DpaW	Former Western Australian Department of Parks and Wildlife (now DBCA)
DPIRD	Western Australian Department of Primary Industries and Regional Development
DPLH	Western Australian Department of Planning, Lands and Heritage
DRIMS	Document Retrieval Integrated Management System
DSEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now DoEE)
eCAR	Environmental Commitments and Actions Register

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Acronym	Description
EET	Emission Estimation Techniques
EEZ	Exclusive Economic Zone
EMBA	Environment that may be affected
ENVID	Environment Identification (study)
EP	Environment Plan
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPO	Environmental Performance Objective
EPS	Environment Performance Standard
ER	Emergency Response
ERP	Emergency Response Plan
ESD	Ecologically Sustainable Development
FFS	Fitness for Services
FPSO	Floating production, storage, and offtake
g	Gram
GEL	Gas Export Line
GP	Good Practice
GWA	Goodwyn Alpha
ha	Hectare
HAZID	Hazard identification (study)
HP	High Pressure
HQ	Hazard Quotient
HSE	Health, Safety, and Environment
HSEC	Health, Safety and Environment Coordinator
HSEQ	Health, Safety, Environment, and Quality
HT	High Temperature
HVAC	Heating, ventilation, and air conditioning
ICSS	Integrated Control and Safety System
IMMR	Inspection, maintenance, monitoring, and repair
IMS	Invasive Marine Species
IMSMP	Invasive Marine Species Management Plan
IPIECA	International Petroleum Industry Environmental Conservation Association
ISO	International Organization for Standardization
ISSoW	Integrated Safe System of Work
ITF	Indonesian Throughflow
ITOPF	International Tanker Owners Pollution Federation Ltd
IUCN	International Union for the Conservation of Nature
KEF	Key Ecological Feature

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Acronym	Description
kg	Kilogram
KGP	Karratha Gas Plant
kHz	Kilohertz
km	Kilometre
kn	Knot
KO	Knock Out (drum)
KPI	Key Performance Indicator
kW	Kilowatt
L	Litre
LAT	Lowest Astronomical Tide
LCS	Legislation, Codes and Standards
LHM	Lambert Hermes manifold
LNG	Liquefied Natural Gas
LP	Low Pressure
LT	Low Temperature
LTO	Licence to Operate
m	Metre
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre
MAE	Major Accident Event
MAH	Monocyclic Aromatic Hydrocarbon
MARPOL	The International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978.
MBES	Multibeam Sonar
MC	Measurement Criteria
MEE	Major Environmental Event
MEG	Monoethylene glycol
mg	Milligram
MGO	Marine Gas Oil
ml	Millilitre
MMscfd	Million standard cubic feet per day
MNES	Matters of National Environmental Significance
MoC	Management of Change
MOPO	Manual of Permitted Operation
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MPRA	Marine Parks and Reserves Authority
MSPS	Management System Performance Standards

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Acronym	Description
MVA	Megavolt-ampere
MW	Megawatt
n.d.	No date
N/A	Not Applicable
N_2O	Nitrous oxide
NERA	National Energy Resources Australia
NGERS	National Greenhouse and Energy Reporting Scheme
NIMS	Non-indigenous Marine Species
nm	Nautical mile
NMFS	National Marine Fisheries Service (US)
NOAA	National Oceanic and Atmospheric Administration (US)
NOEC	No observed effect concentrations
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NORM	Naturally Occurring Radioactive Material
NO_X	Oxides of nitrogen
NPI	National Pollutant Inventory
NRA	North Rankin Alpha
NRC	North Rankin Complex
NSW	New South Wales
NWMR	North-west Marine Region
NWS	North West Shelf
OCIMF	Oil Companies International Marine Forum
OCNS	Offshore Chemical Notification Scheme
OIM	Offshore Installation Manager
OIW	Oil in water
OMDAMP	Offshore Marine Discharges Adaptive Management Plan
OPEA	Oil Pollution Emergency Arrangements
OPEP	Oil Pollution Emergency Plan
OPEX	Operating Expenditure
OPGGS Act	Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OSPAR	Oslo–Paris Convention for the Protection of the Marine Environment of the North East Atlantic
PAH	Polycyclic aromatic hydrocarbon
PAR	Photosynthetically active radiation
PARCOM	former Paris Convention 1997/16
PAU	Pre-assembled unit
PC	Protection Concentration; e.g. PC99 is 99% protection concentration, PC95 is 95% protection concentration etc.

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Acronym	Description
PEC	Predicted Effects Concentration
pH	Measure of acidity or basicity of a solution
PJ	Professional Judgement
PMST	Protected Matters Search Tool
PNEC	Predicted No Effect Concentration
PPA	Pearl Producers Association
ppb	Parts per billion
ppm	Parts per million
PSM	Process Safety Management
PSRA	Process Safety Risk Assessment
PSU	Practical salinity unit
PSZ	Petroleum safety zone
PTS	Permanent threshold shift
PW	Produced Water
RBA	Risk-based Analysis
RBI	Risk-based Inspection
RCC	Rescue Coordination Centre
RESDV	Riser Emergency Shutdown Valve
rms	Root Mean Square
RO	Reverse osmosis
ROV	Remotely operated vehicle
RTM	Riser turret mooring
SA	South Australia
SBP	Sub-bottom profiler
SCE	Safety and Environmental Critical Element
SCM	Subsea Control Module
SCQ	Safety and Environmental Critical Equipment
SCSSV	Surface controlled subsurface safety valve
SEL	Sound Exposure Level
SIMAP	Spill Impact Mapping and Analysis program
SKM	Sinclair Knight Mertz (company)
sm^3	Standard cubic metres
SMP	Scientific Monitoring Program
SOPEP	Ship Oil Pollution Emergency Plan
SO_X	Sulfur oxides
SPL	Sound Pressure Level
SSPL	Subsea Pipeline
SSS	Side Scan Sonar

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Acronym	Description
SV	Societal Value
SVP	Senior Vice President
T	Tonne
TEG	Triethylene glycol
TRC	Total Residual Chlorine
TTS	Temporary threshold shift
UK	United Kingdom
UPS	Uninterrupted Power Supply; battery power system
US	United States
USBL	Ultra-short baseline
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VP	Vice President
VRU	Vapour recovery unit
WA	Western Australia
WAF	Water-accommodated fraction
WAFIC	Western Australian Fishing Industry Council
WANPE	Wanaea Pipeline End
WC GEL	Wanaea Cossack Gas Export Line
WEL	Woodside Energy Limited
WET	Whole Effluent Toxicity
WGS84	Word Geodesic System 1984
WHA	World Heritage Area
WMS	Woodside Management System
WOMP	Well Operations Management Plan

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APPENDIX A WOODSIDE HEALTH, SAFETY, ENVIRONMENT AND QUALITY AND RISK MANAGEMENT POLICIES

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WOODSIDE POLICY

woodside

Health, Safety, Environment and Quality Policy

OBJECTIVES

Strong health, safety, environment and quality (HSEQ) performance is essential for the success and growth of our business. Our aim is to be recognised as an industry leader in HSEQ through managing our activities in a sustainable manner with respect to our workforce, our communities and the environment.

At Woodside we believe that process and personal safety related incidents, and occupational illnesses, are preventable. We are committed to managing our activities to minimise adverse health, safety or environmental impacts, incorporating a right first time approach to quality.

PRINCIPLES

Woodside will achieve this by:

- implementing a systematic approach to HSEQ risk management
- complying with relevant laws and regulations and applying responsible standards where laws do not exist
- setting, measuring and reviewing objectives and targets that will drive continuous improvement in HSEQ performance
- embedding HSEQ considerations in our business planning and decision making processes
- integrating HSEQ requirements when designing, purchasing, constructing and modifying equipment and facilities
- maintaining a culture in which everybody is aware of their HSEQ obligations and feels empowered to speak up and intervene on HSEQ issues
- undertaking and supporting research to improve our understanding of HSEQ and using science to support impact assessments and evidence based decision making
- taking a collaborative and pro-active approach with our stakeholders
- requiring contractors to comply with our HSEQ expectations in a mutually beneficial manner
- publicly reporting on HSEQ performance

APPLICATION

Responsibility for the application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this policy in non-operated joint ventures.

This policy will be reviewed regularly and updated as required.

December 2015

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WOODSIDE POLICY

Risk Management Policy

OBJECTIVES

Woodside recognises that risk is inherent to its business and that effective management of risk is vital to delivering on our objectives, our success and our continued growth. We are committed to managing all risk in a proactive and effective manner.

Our approach to risk enhances opportunities, reduces threats and sustains Woodside's competitive advantage.

The objective of our risk management system is to provide a consistent process for the recognition and management of risks across Woodside's business. The success of our risk management system lies in the responsibility placed on everyone at all levels to proactively identify, manage, review and report on risks relating to the objectives they are accountable for delivering.

PRINCIPLES

Woodside achieves these objectives by:

- Applying a structured and comprehensive risk management system across Woodside which establishes common risk management understanding, language and methodology
- Identifying, assessing, monitoring and reporting risks to provide management and the Board with the assurance that risks are being effectively identified and managed
- Ensuring risks consider impacts across the following key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural
- Understanding our exposure to risk and applying this to our decision making
- Embedding risk management into our critical business activities and processes
- Assuring the effectiveness of risk controls and of the risk management process
- Building our internal resilience to the effects of adverse business impacts in order to sustain performance.

APPLICATION

The Managing Director of Woodside is accountable to the Board of Directors for ensuring this policy is effectively implemented.

Managers are responsible for promoting and applying the Risk Management Policy. Responsibility for the effective application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control.

This policy will be reviewed regularly and updated as required.

December 2012

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APPENDIX B RELEVANT REQUIREMENTS

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APPENDIX C EPBC ACT PROTECTED MATTERS SEARCH REPORTS

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APPENDIX D OIL SPILL PREPAREDNESS AND RESPONSE STRATEGY SELECTION AND EVALUATION

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APPENDIX E NOPSEMA REPORTING FORMS

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APPENDIX F STAKEHOLDER CONSULTATION PHASE I

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APPENDIX G DEPARTMENT OF PLANNING LAND, HERITAGE AND ABORIGINAL ENQUIRY SYSTEM RESULTS

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APPENDIX H OIL POLLUTION FIRST STRIKE PLAN

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