Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (OSMP)

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114

Revision: 1

Issue date: 04/10/2022

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (OSMP) has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head project.

Approval: Triangle Energy (Operations) Pty Ltd

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References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
ANOVA	Analysis of Variance
ASP	Arrowsmith Stabilisation Plant
BACI	Before-After Control-Impact
CHA	Cliff Head Alpha
DMP	Department of Mines and Petroleum
DoT	Department of Transport
EMBA	Environment that May Be Affected
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
HSEQ	Health, Safety, Environment, & Quality
IMT	Incident Management Team
MANOVA	Multivariate Analysis of Variance
MDS	Multidimensional Scaling
MNES	Matters of National Environmental Significance
NEBA	Net Environmental Benefit Analysis
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational And Scientific Monitoring Plan
OSRA	Oil Spill Response Atlas
PCA	Principal Components Analysis
RPD	Relative Per Cent Difference
SMP	Scientific Monitoring Plan
TEO	Triangle Energy (Operations) Pty Ltd
BC Act	*Biodiversity Conservation Act 2016*

IN THE EVENT OF A SPILL – REFER TO THE FLOWCHART OVERLEAF (Figure 1) TO DETERMINE THE NEED FOR OPERATIONAL AND SCIENTIFIC MONITORING

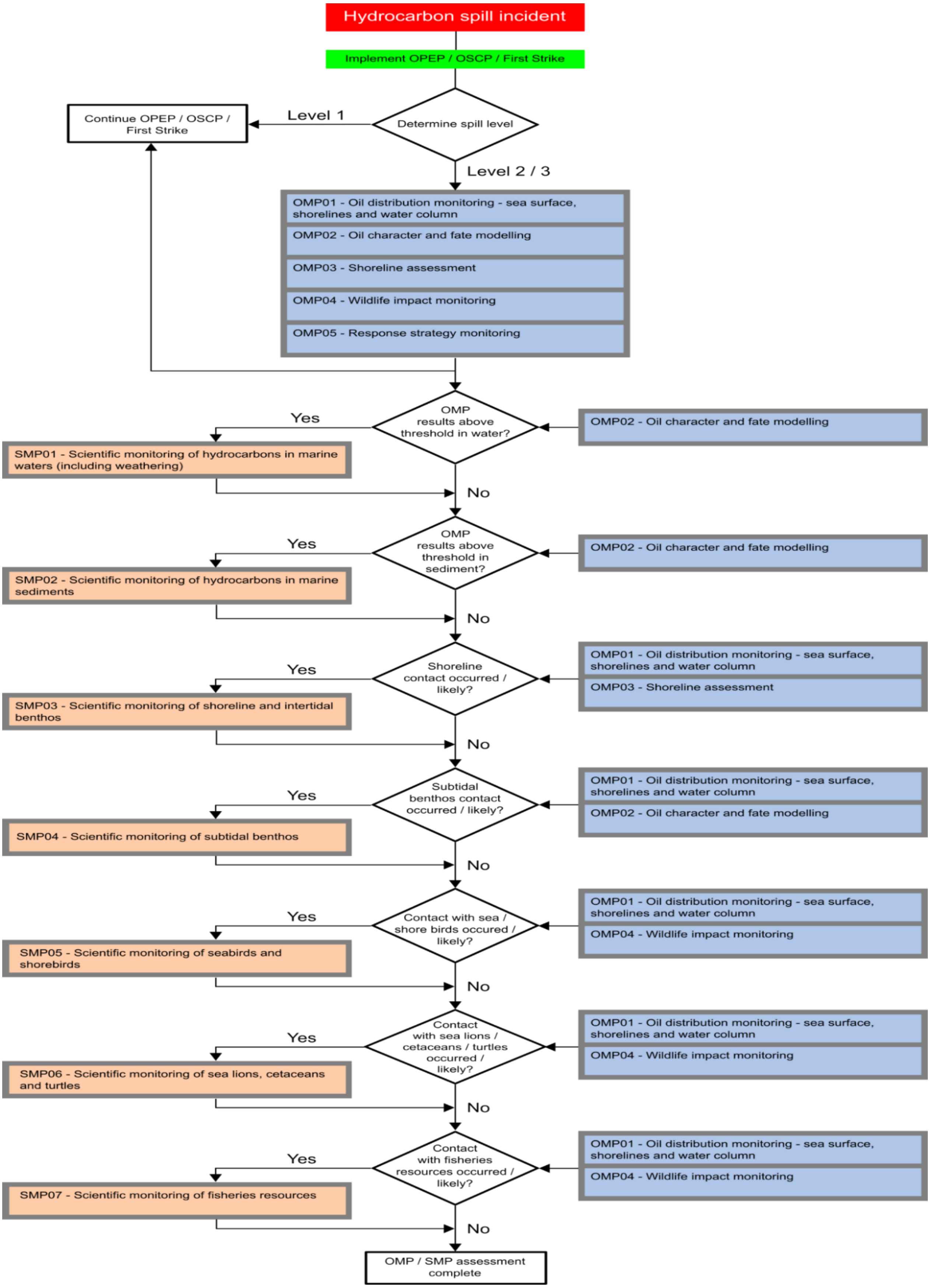

Figure 1 – OSMP flow chart

1 Introduction

Triangle Energy (Operations) Pty Ltd (TEO) operates the Cliff Head Oil Field located off the Western Australian coast, approximately 20 kilometres (km) south of the town of Dongara. The Cliff Head project consists of several offshore and onshore elements:

- The Cliff Head Alpha (CHA) wellhead platform (located in Commonwealth waters)
- A series of subsea production and water injection wells tied back to the CHA platform (located in Commonwealth waters)
- The Arrowsmith stabilisation plant (ASP) (located onshore)
- Subsea production export pipeline, produced water injection pipeline and chemical supply umbilical (with electrical control umbilical) extending between CHA and ASP, traversing Commonwealth and state waters

As an operator of a petroleum production facility, TEO has developed a response framework to manage the environmental risks and impacts associated with hydrocarbon spills associated with the operation and maintenance of the CHA facility and related infrastructure on the marine environment. This includes:

- Environmental Plans, which identify, assess and manage environmental risks and impacts (including a hydrocarbon spill risk assessments) of the Cliff Head development:
    - Cliff Head Offshore Operations Environmental Plan (10HSEQENVPL01)
    - Cliff Head Field State Offshore Environment Plan (10HSEQENVPL11).
- Oil pollution response plans (including Oil Pollution Emergency Plan(s) (OPEPs) and Oil Spill Contingency Plan(s) (OSCPs)). TEO implements a tiered response for oil spills to the marine environment, which is consistent with the Levels described in the National Plan for Maritime Environmental Emergencies (AMSA 2020).
- A series of operational and scientific monitoring plans, consisting of:
    - Five Operational Monitoring Plans (OMPs)
    - Seven Scientific Monitoring Plans (SMPs)
    - An overarching Operational and Scientific Monitoring Plan (OSMP) linking the OMPs and SMPs (this document).

While this overarching OSMP and the associated OMPs and SMPs are written to cover the environmental sensitivities identified during the hydrocarbon spill risk assessment, additional sensitivities that were not identified may be identified. In the unlikely event this occurs, these sensitivities should be monitored in accordance with the framework provided in this OSMP.

1.1 Types of Monitoring

Monitoring of the environmental effects of oil spills and oil spill response activities in Australian waters is often conceptually classified into two groups –operational (or Type I) and scientific (Type II) monitoring (Australian Maritime Safety Authority (AMSA) 2003). TEO maintains this distinction in this OSMP, with the types of monitoring described as:

- Operational (Type I): Operational monitoring is intended to provide information that is used by spill responders and the Incident Management Team (IMT) during the response phase. Operational monitoring is intended to be implemented as soon as practical following a Level 2 or Level 3 oil spill (refer to the OSCP / OPEP for a description of spill levels / tiers). Operational monitoring results are also used to inform the design of SMPs. Operational monitoring does not extend beyond the termination of the operational response to a spill. The series of five OMPs developed by TEO constitute operational monitoring.
- Scientific (Type II): Scientific monitoring is not directly associated with the spill response (although data collected by scientific monitoring may be used by the IMT is the spill response

is ongoing). Rather, scientific monitoring is intended to provide a qualitative assessment of the environmental impacts from an oil spill (and response activities), along with the subsequent recovery of the environment following a spill. Scientific monitoring may continue on for long periods of time after the termination of the operational response to a spill. The series of seven SMPs developed by TEO constitute scientific monitoring.

Once initiated, monitoring of the hydrocarbon spill and environmental resources at risk may include pre-exposure monitoring, post-exposure monitoring and recovery monitoring (Figure 2).

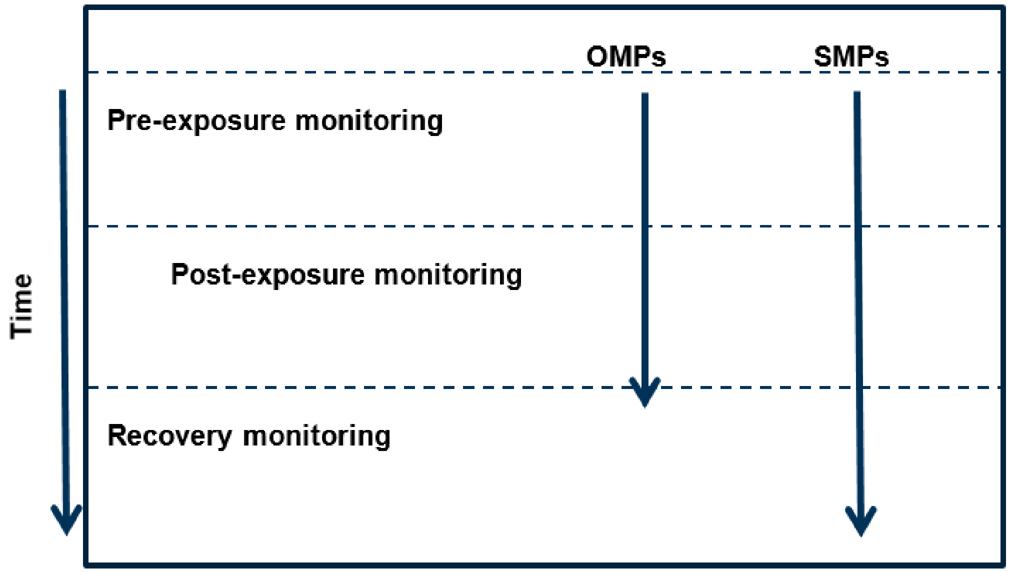

Figure 2 - OMP and SMP implementation over time

1.2 Objectives

The objectives of the overarching OSMP and discrete OMPs and SMPs are to provide a monitoring response in the event of a hydrocarbon spill that:

- Assists in implementing the response strategies in the OSCPs / OPEPs
- Quantifies the changes in the environment that may be attributed to an oil spill
- Determining if/when the environmental performance objectives / environmental performance outcomes are met (Section 6).

1.3 Interface with other plans

This overarching OSMP interfaces with a number of existing documents (summarised in Table 1), including:

- Environment Plans
- OSCPs / OPEPs
- OMPs
- SMPs.

Table 1 - OMP and SMP implementation over time

Title	Document type	Document Number	Relevance
Cliff Head Offshore Operations Environmental Plan	Environment Plan	10HSEQENVPL01	Contains hydrocarbon spill risk assessment for Cliff Head operations in Commonwealth waters
Cliff Head Field State Offshore Environment Plan		10HSEQENVPL11	Contains hydrocarbon spill risk assessment for Cliff Head operations in State waters

Title	Document type	Document Number	Relevance
Cliff Head Alpha Operations Oil Pollution Emergency Plan (OPEP)	OPEP	10HSEQENVPL15	OPEP supporting Operations and IMR activities in Commonwealth waters. Contains response arrangements in the event of hydrocarbon The determination of the level of a spill is made during implementation of the OPEP; Level 2 or 3 spills are triggers for OMP implementation.
Cliff Head Alpha Operations Oil Spill Contingency Plan	OSCP	10HSEQENVPL02	OSCP supporting the Operations EP in State waters. The determination of the level of a spill is made during implementation of the OSCP; Level 2 or 3 spills are triggers for OMP implementation.
OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column	OMP	4716-HS-H0114-01	OMPs supporting this overarching OSMP, each with discrete initiation and termination criteria. OMPs are intended to support the operational response to an oil spill. Refer to Section 6 for additional information.
OMP-02 – Oil Character and Fate Modelling		4716-HS-H0114-02	
OMP-03 – Shoreline Assessment		4716-HS-H0114-03	
OMP-04 – Wildlife Impact Monitoring		4716-HS-H0114-04	
OMP-05 – Response Strategy Monitoring		4716-HS-H0114-05	
SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)	SMP	4716-HS-H0114-11	SMPs supporting this overarching OSMP, each with discrete initiation and termination criteria. SMPs are intended to quantify the changes to the environment (both short and longer term) due to, and the recovery following, an oil spill. Refer to Section 8 for additional information.
SMP-02 - Scientific monitoring of hydrocarbons in marine sediments		4716-HS-H0114-12	
SMP-03 - Scientific monitoring of shoreline and intertidal benthos		4716-HS-H0114-13	
SMP-04 - Scientific monitoring of subtidal benthos		4716-HS-H0114-14	
SMP-05 - Scientific monitoring of seabirds and shorebirds		4716-HS-H0114-15	
SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles		4716-HS-H0114-16	
SMP-07 - Scientific monitoring of fisheries resources		4716-HS-H0114-17	

1.4 Contact information

Contact information for key agencies and personnel relevant to this OSMP and associated OMPs and SMPs can be found in Table 1.6 of the CHA Operations Oil Pollution Emergency Plan (OPEP) (10HSEQENVPL15). In the event of implementation of this OSMP, personnel responsible for implementation should seek additional or more recent contact details from the IMT.

2 Hydrocarbon Spill Risk Assessment

Hydrocarbon spill risk assessments relating to the Cliff Head project have been documented in the EPs (and associated documents) outlined in Table 1. The credible spill scenarios assessed in each of these documents are summarised in Table 2. Refer to the relevant hydrocarbon spill risk assessment in the associated environmental management documents for additional details.

Table 2 – Summary of maximum credible spill scenarios assessed in relation to Cliff Head development

Scenario	Oil Type	Maximum Volume	Release Type	Release Location
Small spillages (CHA platform and vessels)[1,2]	Diesel, hydraulic oil, lubricating oil	<2 m^3	Instantaneous	CHA Vessels
Pipeline leak (operations) – undetected (small hole) [1, 2]	Cliff Head crude	97 m^3	4.6 m^3 per day for 21 days	Pipeline corridor
Vessel spill[1, 2]	Marine diesel	500 m^3	Instantaneous	Adjacent to CHA, pipeline corridor
Topsides process leak[1]	Cliff Head crude	84.3 m^3	0.136 m^3/hour over 21 days	CHA
Note 1 - Cliff Head Offshore Operations Environmental Plan (10HSEQENVPL01) Note 2 - Cliff Head Field State Offshore Environment Plan (10HSEQENVPL11)				

The EMBA based on the stochastic spill modelling represents a probabilistic approach to determining the EMBA, however a spill event will affect only a portion of the EMBA. While considered unlikely, a spill may also extend beyond the EMBA identified in the hydrocarbon spill risk assessments. As such, the OMPs and SMPs are adaptable and can be applied in areas beyond the EMBA if required.

2.1 Hydrocarbons in the marine environment

The hydrocarbon types that can credibly result in a spill requiring the implementation of OMPs or SMPs are marine diesel and Cliff Head crude. Marine diesel is relatively light oil with a high portion of volatile fractions, with a large portion (~50%) expected to evaporate within several hours of the discharge, with the residual fraction remaining on the water surface or becoming entrained (Asia-Pacific Applied Science Associates 2017). Cliff Head crude is a persistent, viscous oil that is expected to lose approximately 21% of its volume over the first day. Approximately, 55% of the crude oil is considered persistent and will likely solidify over time and turn to wax after weeks in the marine environment (RPS 2022). Given the high viscosity of Cliff Head crude oil, it is not expected to become entrained and instead will form tar balls. Refer to the Cliff Head Offshore Operations Environmental Plan (10HSEQENVPL01) for additional information on marine diesel and Cliff Head crude oil.

The fates of spilled hydrocarbons in the marine environment are summarised in Table 3. For further discussion refer to the hydrocarbon risk assessments in the EPs provided in Table 1.

Table 3 – Fates of spilled hydrocarbons in the marine environment

Scenario	Oil Type
Spreading	Surface hydrocarbon spills will begin to spread immediately upon being released. The rate at which a hydrocarbon slick spreads largely depends on the viscosity of the hydrocarbon, with lower viscosity hydrocarbons spreading more rapidly. Spreading is also influenced by metocean conditions (waves, wind, tides and currents), with increased turbulence typically resulting in faster spreading (and potentially entrainment). Spreading oil is exposed to the atmosphere, with volatile fractions evaporating from the slick, reducing the amount of surface oil.
Evaporation	Volatile components of a hydrocarbon spill will evaporate to the atmosphere, with increased wind speeds and ambient temperatures resulting in an increased evaporation rate. Lighter hydrocarbon fractions (BP <200 °C) will typically evaporate entirely within 24 hours in temperate conditions. The surface area of a slick (determined by the spread of the slick) also influences the rate at which it will evaporate, with larger surface areas increasing the evaporation rate. Remaining hydrocarbons will have a higher density and viscosity, which will affect how the remaining spill behaves.
Dispersion / entrainment	Spilled hydrocarbons may become dispersed (also referred to as entrained), which is characterised by droplets of oil becoming mixed in the water column. The height within the water column of entrained oil depends on the release location, with subsea released potentially being entrained throughout the entire water column, while entrained oil from surface released is concentrated near the surface. Dispersion occurs more readily with relatively low viscosity oils in the presence of breaking waves. When metocean conditions are no longer suitable to sustain entrainment, dispersed oil will typically return to the sea surface, with the rate of return influenced by the buoyancy of the oil droplets (which is a function of the oil density). Once on the sea surface, droplets that were previously entrained will form a slick.
Emulsification	In spilled persistent oil (i.e. oil that does not degrade / evaporate easily), water droplets may become dispersed within the oil slick, creating an emulsion. Emulsified oil typically takes on a mousse-like appearance and can increase in volume. Emulsion can also become more viscous and dese in comparison to the source oil. Emulsification tends to occur in relatively heavy oils and is not expected to account for a significant portion of marine diesel fuel or Cliff Head crude in the event of a spill.
Dissolution	While the majority of components within the hydrocarbons that may credibly be spilled during the activity are not water soluble, some components may dissolve in sea water. The lighter fractions of the oil are typically more soluble (e.g. aromatic hydrocarbons), and these are generally more toxic than the heavier fractions. Lighter fractions are also more volatile and will typically evaporate quickly. Given the relatively small portion of soluble hydrocarbons present in marine diesel fuel and Cliff Head crude, along with their rapid decomposition, the percentage of spilled oil that may dissolve in the spill scenarios considered in this EP is considered to be low.
Sedimentation	Dispersed oil particles can bind with suspended particulate matter and sink to the seabed. This tends to occur with heavy persistent oils and is not expected to account for a significant portion of oil in the event of a spill.
Photo-oxidation	Reactions of spilled hydrocarbons with oxygen, catalysed by sunlight, may lead to the formation of soluble or persistent tars. The effect of photo-oxidation on the fate of a hydrocarbon spill is typically small, with the breakdown of thin oil films by photo-oxidation typically accounting for <0.1% of hydrocarbon mass per day.
Biodegradation	Sea water hosts a range of microorganisms that can utilise hydrocarbons as a carbon source for metabolism, breaking down the oil into water soluble compounds and ultimately to carbon dioxide and water. Biodegradation rates depend on a range of factors, including the characteristics of the oil, surface area of the oil, temperature and nutrient availability. Biodegradation is the ultimate fate for persistent spilled oils, however the process may take considerable time, particularly for persistent oil that becomes trapped in sediments.

3 Environmental Sensitivities

The environmental sensitivities within the EMBA identified by the hydrocarbon spill risk assessments are summarised in the EPs outlined in Table 1 and summarised in Appendix C. The EPs which are supported by this OSMP and associated OMPs and SMPs identify a series of environmental sensitivities, including:

- Species of conservation significance, including:
  - Matters of national environmental significance (MNES) as identified under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
  - Specially protected fauna or flora gazetted under the Biodiversity Conservation Act 2016 (BC Act)
- Protected areas, including:
  - Commonwealth marine reserves
  - State marine protected areas
- Socio-economic resources, including:
  - Commonwealth managed fisheries
  - State managed fisheries.

TEO maintains an environmental data directory which contains information on the environmental sensitivities that may be affected in the event of a spill. The data directory is located on the TEO server at the following network path:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

TEO has access to the Oil Spill Response Atlas (OSRA), which is maintained by AMSA with support from the Western Australian Department of Transport (DoT). Access to the OSRA is available at http://www.transport.wa.gov.au/imarine/planning-tools.asp. The log-in details for the ORSA are attached to the inside cover of the hardcopy OPEP kept in the TEO Office (Havelock Street) Incident Control Centre. A digital copy of the ORSA login details is also saved in the environmental data directory.

Additionally, refer to the Cliff Head Offshore Operations Environmental Plan (10HSEQENVPL01) and Cliff Head Field State Offshore Environment Plan (10HSEQENVPL11) for information on the environmental sensitivities within the EMBA for the credible spill scenarios assessed.

4 Environmental Performance Objective / Outcomes

TEO has developed a series of environmental performance objectives / environmental performance outcomes during the development of Environment Plans (EPs) in relation to the Cliff Head project (outlined in Table 1). The relevant environmental performance objectives / environmental performance outcomes are summarised in Table 4.

Table 4 – Environmental performance outcomes / environmental performance objectives

Environmental Performance Objective / Environmental Performance Outcome
No injury or harmful disturbance to marine fauna
To contain and dispose of waste in accordance with legal requirements and re-use and recycle where practicable
Preventable harm does not occur due to hydrocarbon spill response strategies
Select response strategies that result in a net environmental benefit
No IMS introduced from project vessels or in-water equipment to the Operational Area as a result of IMR activities

5 Operational Monitoring

The intent of operational monitoring is two-fold:

(1) Provide information to the IMT to inform decision making during the oil spill response, as detailed in the OSCPs/OPEPs outlined in Table 1.

(2) Determine the initial impacts to the environment to inform the initiation of SMPs (Section 8)

A series of five OMPs have been developed to meet the intent of operational monitoring, as described in Table 4.

5.1 Initiation and termination criteria

Discrete initiation and termination criteria for each of the OMPs are provided in Table 5. Note that all OMPs are implemented in the event of a Level 2 or Level 3 hydrocarbon spill.

5.2 Reporting

Specific reporting requirements are described in each of the OMPs. Reporting from all OMPs should be communicated to the IMT on a regular basis that is sufficient in informing hydrocarbon spill response activities.

5.3 Design considerations for operational monitoring plans

Operational monitoring is intended to be implemented as soon as practicable following a Level 2 or Level 3 oil spill. As such, the OMPs have been designed to be implemented quickly using readily available equipment and techniques. The design of the OMPs is intended to provide indicative data that informs the IMT when making decisions about spill response, as well as determine the need for scientific monitoring.

OMPs are not intended to provide robust scientific data from which quantitative assessments of the impacts of a spill (and spill response) can be made; that is the role of the SMPs.

While the OMPs constitute a series of discrete plans, it is expected that all of the OMPs would be implemented concurrently by a scientific team to optimise the use of field resources.

Table 5 – Summary of OMPs, including initiation criteria, termination criteria, inputs and outputs

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs to Other Documents / Plans
OMP01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column (4716-HS-H0114-01)	Determines the spatial extent of the hydrocarbon spill during the spill response, including: • Current extent of spilled oil (including surface, entrained and dissolved fractions) • Projected trajectory of spilled oil (by in field assessments and modelling studies)	Level 2 or level 3 hydrocarbon spill (as determined by process described in OSCP / OPEP)	Confirmation that source is controlled AND The incident response has been terminated by the IMT OR The information acquired by implementation of OMP01 no longer informs decision making by the IMT.	Release location Release time Hydrocarbon type (either vessel fuel or Cliff Head crude) Estimated volume of spilled hydrocarbon	All other OMPs All other SMPs OSCP / OPEP, including Net Environmental Benefit Analysis (NEBA)
OMP02 – Oil Character and Fate Modelling (4716-HS-H0114-02)	Described the fate of spilled oil, and considered the following fates: • Surface • Entrained • Dissolved • Stranded Uses field observations and sample analysis, as well as numerical modelling.		Confirmation that source is controlled AND The incident response has been terminated by the IMT OR The information acquired by implementation of this OMP no longer informs decision making by the IMT OR SMP monitoring that superseded this OMP (i.e. SMP01 and SMP02) has commenced.	Release location Release time Hydrocarbon type Estimated volume of spilled hydrocarbon Current and previous distribution of hydrocarbons from the spill based on operational monitoring plan (OMP01).	OMP03 – Shoreline assessment OMP04 – Wildlife impact monitoring OMP05 – Response strategy monitoring All SMPs OSCP / OPEP, including NEBA

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs to Other Documents / Plans
OMP03 – Shoreline Assessment (4716-HS-H0114-03)	Determines the nature and extent of hydrocarbon contamination on shorelines.		Confirmation that source is controlled AND The incident response has been terminated by the IMT OR The information acquired by implementation of this OMP no longer informs decision making by the IMT OR SMP03 – Scientific monitoring of shoreline and intertidal benthos has been implemented	Release location Release time Hydrocarbon Estimated volume of spilled hydrocarbon Spill tracking / trajectory (OMP01) Oil fate assessment (OMP02)	OSCP / OPEP – shoreline clean up response
OMP04 – Wildlife Impact Monitoring (4716-HS-H0114-04)	Provides an assessment of the impacts of spilled hydrocarbons on wildlife during the response phase. Assists in developing the oiled wildlife response (if implemented).		Confirmation that source is controlled AND The incident response has been terminated by the Incident Management Team (IMT) OR The information acquired by implementation of this OMP no longer informs decision making by the IMT OR Implementation of SMPs supersedes this OMP: • SMP05 – Scientific monitoring of seabirds • SMP06 – Scientific monitoring of sea lions, cetaceans and turtles • SMP07 – Scientific monitoring of fisheries resources.	Release location Release time Hydrocarbon type (either vessel fuel or Cliff Head crude) Estimated volume of spilled hydrocarbon Current and previous distribution of hydrocarbons from the spill (OMP01) The predicted spill trajectory (OMP02) Known or suspected fauna distributions based on available data (e.g. Oil Spill Response Atlas, Environment Plans, Overarching OSMP) Any observations of marine fauna exposed or at risk made during spill response activities.	Scientific monitoring of seabirds and shorebirds (SMP05) Scientific monitoring of sea lions, cetaceans and turtles (SMP06) Scientific monitoring of fisheries (SMP07)

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs to Other Documents / Plans
OMP05 – Response Strategy Monitoring (4716-HS-H0114-05)	Monitors the effectiveness of the response strategies that have been selected for implementation.		Confirmation that source is controlled AND The incident response has been terminated by the IMT OR The information acquired by implementation of this OMP no longer informs decision making by the IMT	Release location Release time Hydrocarbon type (either vessel fuel or Cliff Head crude) Estimated volume of spilled hydrocarbon Current and previous distribution of hydrocarbons from the spill (OMP01) NEBA outcomes (from OSPC / OPEP) Current response strategies implemented (from IMT) Operational information on response strategies (routinely reported to IMT during response).	To IMT: • Whether the current response strategies are effective and are reasonably considered to result in a net environmental benefit • Whether the current response strategies should be continued or terminated

6 Scientific Monitoring

The intent of scientific monitoring is to determine the changes to the environment that have resulted from the hydrocarbon spill, including:

- Short term environmental damage
- Longer term changes to the environment
- Recovery of the environment following changes that can reliably be identified as a result of the hydrocarbon spill.

A series of seven SMPs have been developed to meet the intent of scientific monitoring, as described in Table 6.

While the SMPs constitute a series of discrete plans, it is expected that all of the SMPs would be implemented concurrently by a scientific team to optimise the use of field resources.

6.1 Initiation and termination criteria

Discrete initiation and termination criteria for each of the SMPs are provided in Table 6. Note that initiation of SMPs is routinely linked to the information collected during OMPs. Failure to adequately implement OMPs may inhibit the implementation of SMPs, potentially leading to the failure to undertake scientific monitoring when warranted.

6.2 Reporting

Specific reporting requirements are described in each of the SMPs.

Table 6 – Summary of SMPs, including initiation criteria, termination criteria, inputs and outputs

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs
SMP01 - Scientific monitoring of hydrocarbons in marine waters (including weathering) (4716-HS-H0114-11)	Assess the concentrations of various hydrocarbon fractions in marine water, from which inferences about the nature of hydrocarbon contamination can be made. This information will inform investigations of cause/effect relationships between the oil spill and impacts to natural resources can be identified	OMP01 results indicate that hydrocarbon levels are above threshold values	No statistically significant difference in hydrocarbon concentrations between impact and reference sites.	Current and previous distribution of hydrocarbons from the spill (OMP01) The predicted spill trajectory (OMP01) Concentration of hydrocarbons in water from operational monitoring (OMP01)	Reporting to stakeholders Water quality data for use in other SMPs
SMP02 - Scientific monitoring of hydrocarbons in marine sediments (4716-HS-H0114-12)	Assess the concentrations of various hydrocarbon fractions in marine sediments, from which inferences about the nature of hydrocarbon contamination can be made. This information will inform investigations of cause/effect relationships between the oil spill and impacts to natural resources	OMP01 results indicate that hydrocarbon levels are above threshold values	No statistically significant difference in sediment hydrocarbon concentrations between impact and reference sites.	Current and previous distribution of hydrocarbons from the spill (OMP01) The predicted spill trajectory (OMP02) Concentration of hydrocarbons in sediments from operational monitoring (OMP01)	Reporting to stakeholders Sediment quality data for use in other SMPs
SMP03 - Scientific monitoring of shoreline and intertidal benthos (4716-HS-H0114-13)	Assess the environmental impacts and subsequent recovery resulting from a hydrocarbon release and associated response activities on shoreline and intertidal environments, including: • The presence of beached hydrocarbons • The concentrations of hydrocarbon fractions in sediments • The effects of hydrocarbons on intertidal biota and subsequent recovery	OMP01 or OMP03 indicates shoreline contact has occurred or is likely	No statistically significant difference in sediment hydrocarbon concentrations between impact and reference sites OR Oil pollution effects on benthos are no longer detectable by statistical assessment OR Evidence of key ecological processes (e.g. recruitment) necessary for post-impact recovery is demonstrated	Current and previous distribution of hydrocarbons from the spill (OMP01) The predicted spill trajectory (OMP01) Operational assessment of hydrocarbons in water and sediments (OMP01) Evidence of shoreline contact (OMP03)	Reporting to stakeholders Shoreline assessment potentially used in other SMPs

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs
SMP04 - Scientific monitoring of subtidal benthos (4716-HS-H0114-14)	Assess the environmental impacts and subsequent recovery from a hydrocarbon release on subtidal benthic habitats, including: • Seagrasses • Macroalgae • Sponges / filter feeders • Hard corals • Soft corals	Hydrocarbon spill surveillance or spill trajectory modelling (OMP01) indicate that oil may have contacted, or is likely to contact, benthic habitats OR Evidence of oiling of benthic habitats	Oil pollution effects on benthos are no longer detectable by statistical assessment OR Evidence of key ecological processes (e.g. recruitment) necessary for post-impact recovery is demonstrated	Current and previous distribution of hydrocarbons from the spill (OMP01) The predicted spill trajectory and fate (OMP01 and OMP02) Evidence of oiling of sediments or benthic habitats	Reporting to stakeholders
SMP05 - Scientific monitoring of seabirds and shorebirds (4716-HS-H0114-15)	Assess the impacts and subsequent recovery of seabird and shorebird populations in response to a hydrocarbon spill event and spill response activities	Spilled hydrocarbons overlapping known bird habitat (OMP01 and OMP04) Evidence of oiling of birds (OMP04)	The level of impact to affected seabird and shorebird populations has been quantified OR The impacts to important habitat (feeding, breeding and roosting areas) are not significantly different to reference areas or baseline OR The impacts of the hydrocarbon spill are no longer statistically detectable	Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP01) The predicted spill trajectory and fate (OMP01 and OMP02) Evidence of contact with seabird or shorebirds during operational response (OMP04) Information on the nature of the spilled hydrocarbon over time (SMP01) Areas known to or expected to host seabird and shorebird aggregations	Reporting to stakeholders
SMP06 - Scientific monitoring of sea lions, cetaceans and turtles (4716-HS-H0114-16)	Assess impacts which may have resulted from the hydrocarbon spill to large marine fauna (referred to as significant fauna), including: • Sea lions • Cetaceans • Marine turtles	Spilled hydrocarbons overlapping known significant fauna habitats (OMP01 and OMP04) Evidence of oiling of significant fauna (OMP04)	The level of impact to affected significant fauna populations has been quantified OR The impacts to important habitat (feeding, breeding and migration areas) are not significantly different to reference areas OR The impacts of the hydrocarbon spill are no longer statistically detectable	Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP01) The predicted spill trajectory (OMP01) Evidence of contact with significant fauna during operational response (OMP04) Areas known to or expected to host significant fauna	Reporting to stakeholders

Plan	Description	Initiation Criteria	Termination Criteria	Inputs	Outputs
SMP07 - Scientific monitoring of fisheries and tourism resources (4716-HS-H0114-17)	Quantify the potential contamination and tainting of fisheries resources (including finfish, elasmobranchs, shellfish and crustaceans) exploited by commercial and recreational fishers from hydrocarbon exposure/contact	Contact with fisheries / tourism resources occurred or likely (e.g. evidence of fish kills)?	The level of impact to affected fish and shellfish populations has been quantified OR The impacts to important fisheries resources are not significantly different to reference areas or baseline OR The impacts of the hydrocarbon spill are no longer statistically detectable	Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP01) The predicted spill trajectory (OMP01) Evidence of contact with fisheries resources during operational response (OMP04) Areas known to or expected to host fisheries resources	Reporting to stakeholders

6.3 Design considerations for scientific monitoring plans

Unlike the OMPs, which are intended to provide information to assist in responding to a spill, SMPs are intended to provide robust, quantitative information on the changes to the environment due to an oil spill. In order to do this in a robust, defensible way, there are additional design considerations when planning the implementation of SMPs. While considerations particular to specific SMPs are detailed in the relevant SMP, there are a several overarching scientific principles that should be considered during the design and implementation of all SMPs, which are discussed below, including:

- The logic of the monitoring program
- Selection of monitoring parameters
- Selection of sites
- Baseline data
- Statistical power
- Replication

Design considerations for SMPs to verify that scientifically robust data are collected, and valid inferences on the nature of potential oil replated impacts are made, is a complex topic (Table 7). SMP design should always involve consultation with suitably qualified and experienced marine scientists that have an understanding of the principles of monitoring design. Excellent discussions of the considerations of monitoring program design applicable to the marine environment can be found in Quinn and Keough (2002) and Underwood (1997).

Table 7 – Considerations for the design of scientific monitoring programs

Principle	Description
Develop sound logical framework for monitoring program design (Section 6.3.1)	Develop clear logical frameworks (i.e. logical and statistical hypotheses) for assessing the effects of oil-related impacts on receptors. Where practical, incorporate comparison between independent control and impact sites over time, with adequate replication within sites. Where practicable, incorporate baseline (i.e. pre-exposure) sampling into the monitoring program design.
Select appropriate monitoring parameters (Section 6.3.2)	Select monitoring parameters that are directly (e.g. hydrocarbon concentrations in sediment, water, tissue etc.) or indirectly (e.g. liver function in biota) linked to hydrocarbon exposure, with clear pathways of impact. Select parameters for which accurate, precise monitoring and analytical techniques are available to reduce variability in samples due to measurement.
Select sites that meet the requirements of the logical framework of the monitoring program (Section 6.3.3)	Monitoring sites should be selected in accordance with the logical design of the monitoring program. This is expected to include monitoring of impact (i.e. sties exposed to oil) and control (i.e. sites unexposed to oil), with a suitable number of sites monitored to attain sufficient statistical power if conducting test (refer to Section 6.3.5 for additional information). Stratify sampling by matching sites or samples within sites along environmental gradients, habitat types etc. to reduce variability. Where required for statistical analysis, sample with the same intensity within each site to facilitate balanced monitoring program designs.
Incorporate baseline data where practicable (Section 0)	Where existing data are available and can be used to inform a monitoring program, they should be considered. Where baseline data are available, monitoring should be carried out using the same methodology to reduce the variability between baseline and monitoring data due to sampling technique. Where baseline data are not available, monitoring should consider acquiring pre-exposure data in areas that are within the spill trajectory to serve as baseline data. Where baseline data cannot be collected, the logical framework of the monitoring program should be adjusted accordingly and care should be taken when making inferences where baseline data are not available. Refer to Sections 6.3.1 and 0 or additional information.

Principle	Description
Quantify statistical power prior to developing monitoring programs (Section 6.3.5)	If the monitoring program incorporates statistical tests (e.g. testing statistics from impact sites against control sites or threshold values), a consideration of the Type I and Type II error rates should be made, including power analysis to inform the design of the monitoring program.

6.3.1 Monitoring program logic

SMPs often rely on statistical tests to make inferences about the nature of an impact, frequently by comparing reference (or control) sites with sites that have been impacted or potentially exposed to hydrocarbons. While the statistical model used during the analysis of SMP data may vary and will be selected by the scientist(s) involved in the design of the SMP, the following discussion is valid for the statistical frameworks that may reasonably be implemented.

Developing a statistical model (i.e. a way of predicting the response of an environmental parameter), and from this developing a statistical hypothesis that can be tested, is a key consideration in developing scientific monitoring programs. The process by which this can be done is described in Figure 3. Failure to develop clearly testable hypotheses based on models that are related to the effects of oil on the environment may result in:

- Implementation of studies which do not provide adequate data from which valid inferences on the impacts of spilled oil can be drawn
- Difficulty in demonstrating to regulatory authorities that the impacts from a spill have been quantified adequately
- Difficulty in justifying the termination of SMPs, potentially leading to unnecessary monitoring.

As such, it is important that the logic behind an SMP be valid and clearly articulated during the development of an SMP.

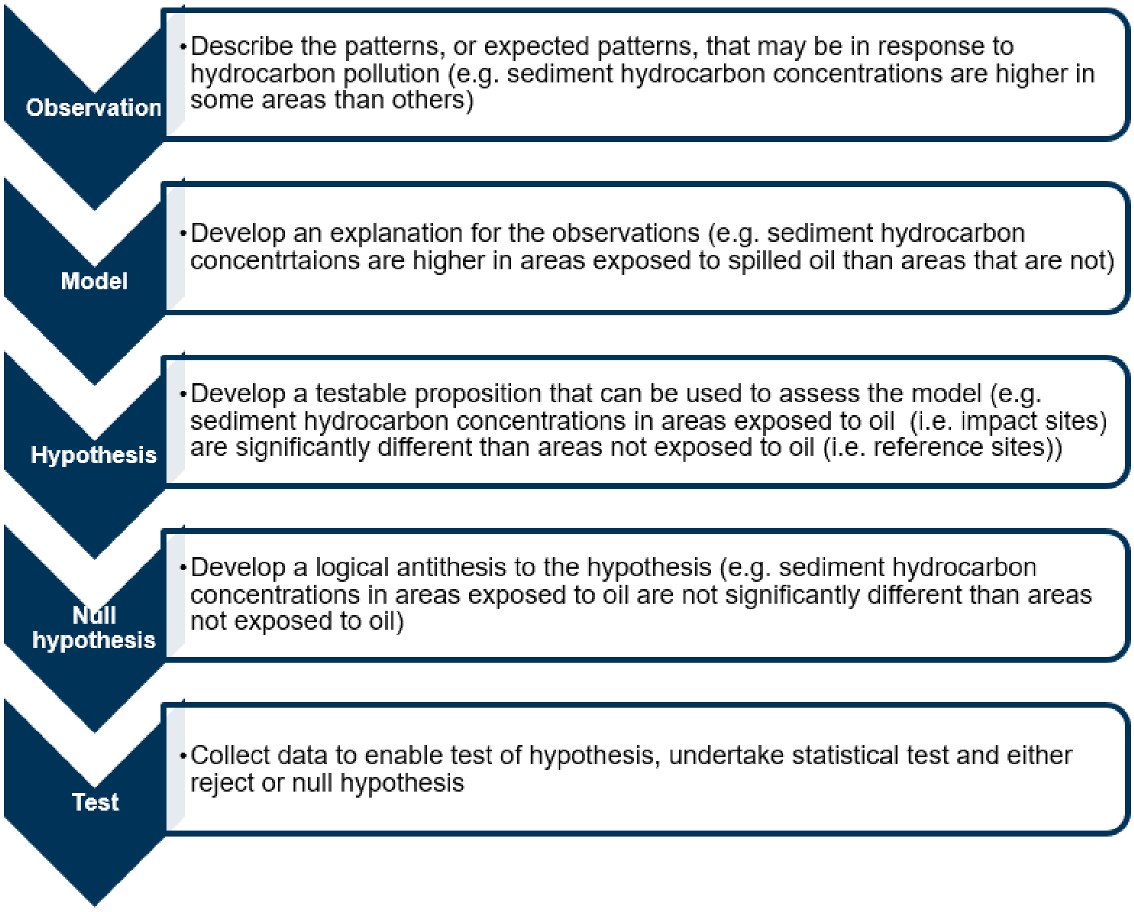

Figure 3 – Sequential stages of logical construction leading to a statistical test for an SMP (adapted from Underwood 1991)

A strong logical framework for detecting changes in the environment is the Beyond Before-After Control-Impact (BACI) approach. This approach required monitoring of a series of reference and impact sites over time (i.e. the Control-Impact component), with all sites monitored prior to and following exposure to spilled hydrocarbons (i.e. the Before-After component). Note that this approach requires considerable data to be collected prior to the impact occurring; refer to Section 5 for a discussion of baseline data. The repeated measures at sites over time are an important component of the analysis to provide replication over time (refer to Section 8.3.5.3 for a discussion of replication).

Where baseline data are not available, alternatives to a BACI-type design may be considered, such as comparison of reference and impacts sites (without the consideration of the before-after component). The inferences that can be drawn from such designs are inherently weaker. For example, if a seagrass meadow exposed to oil had a lower per cent cover than one which was not exposed to oil, caution should be made in drawing the inference that the difference in per cent cover is due to oil exposure. While the evidence available is not inconsistent with this inference, there are a range of reasons as to why the per cent cover may be different, such as grazing pressure, differences in light availability, wave exposure etc. Incorporating a before-after component with spatial and temporal replication (i.e. repeated measures) in the analysis would considerably strengthen such an analysis; if the meadows were similar prior to the impacted meadow being exposed, then the evidence to suggest the decrease in per cent cover is due to the oil is much stronger.

Monitoring impact sites only over time (i.e. a before-after comparison) should be avoided, as it is difficult to ascribe changes observed following the impact to the spilled oil. For example, if monitoring at a single site before and after oil exposure indicated a change in a parameter following the application may lead to an inference that oil resulted in the change. This is a weak inference, as the parameter measures may have changed for a range of reasons in the broader environment, such as natural seasonal variability or other processes such as grazing, predation or recruitment variability.

Comparisons against suitable reference sites, with impact and reference sites monitored over time, should be incorporated into such analyses (i.e. a Beyond BACI design) wherever practicable. Note that monitoring of impact sites over time may be the only reasonable approach for some environmental sensitivities if suitable control sites are not available.

Multivariate analysis (i.e. the simultaneous analysis of multiple variables at once) should be considered where more than one parameter is being measured. Multivariate techniques may include, but are not limited to, multivariate analysis of variance (MANOVA), principal components analysis (PCA) and multidimensional scaling (MDS). Where a single variable is monitored, univariate analyses such as analysis of variance (ANOVA) or t tests may be suitable.

Discussions of the logic of monitoring programs to detect environmental impacts can be found in:

- Experimental design and data analysis for biologists (Quinn and Keough 2002)
- On beyond BACI: sampling designs that might reliably detect environmental disturbances (Underwood 1994)
- Experiments in ecology: their logical design and interpretation using analysis of variance (Underwood 1997).

6.3.2 Selection of monitoring parameters

Monitoring parameters should be defined during the design of any SMP. Suggested parameters are provided in the SMPs provided in Appendix B. The parameter(s) measures should be linked to the hypothesis being tested; the data collected should be able to conduct a valid analysis in relation to the hypothesis or environmental parameter of interest. The monitoring parameters should also be linked to the mechanisms of hydrocarbon impacts (either directly or indirectly).

Destructive sampling methods (e.g. clearing intertidal shorelines during sampling) should be avoided in order to reduce the environmental impact of sampling where possible. Destructive sampling cannot be used for repeat measures monitoring designs.

When monitoring iota, the selection of monitoring parameters should include keystone species (i.e. species that are considered to exert control on ecological processes by playing a unique and crucial role in ecosystem function). Keystone species may include habitat forming biota such as macroalgae and seagrasses.

Indicator species may also be monitored, although this approach is not recommended. Considerations when selecting indicator species include:

- Is the species ubiquitous throughout the EMBA and present year round?
- Are the responses of the indicator species to toil pollution clearly known and consistent?
- Is the response of the species representative of the effects of hydrocarbon pollution in the ecosystem?

When selecting both keystone and indicator species for monitoring, particular care should be taken to avoid a single species, or small suite of species, as such monitoring may not provide an adequate representation of the impacts of oil on the environment.

6.3.3 Selection of sites

A graphical representation of the process to select monitoring sites is presented in Figure 4 Sites should be selected based on their exposure to spilled oil. It is important to reliably identify impact sites that may have been exposed to spilled oil and reference sites that have not been exposed. The results of operational monitoring can be of use in this. Failure to reliably identify impact and control sites may confound the analysis of monitoring results.

Control and impact sites for monitoring should be stratified along environmental gradients where possible, such as depth, wave energy / exposure and substrate type gradients. In particular, functionally equivalent habitats should be sampled within impact and control sites where practicable (i.e. impact seagrass site(s) should be compared to seagrass control site(s) in studies examining benthic habitats more broadly). Following an oil spill, impact sites should be selected first, followed by the selection of matched reference sites. The matching of sites within strata reduces variability and increases the power of the analysis.

Where practicable, replication should include equal numbers of replicates within each group (or factor) used in the analysis and equal numbers of observations within replicates to ensure a balanced monitoring program design. Unbalanced designs may lead to difficulties in interpretation of results due to differences in the precision of the estimates of the sample parameters between groups. Unbalanced designs can be analysed, however balanced designs are preferred where practicable.

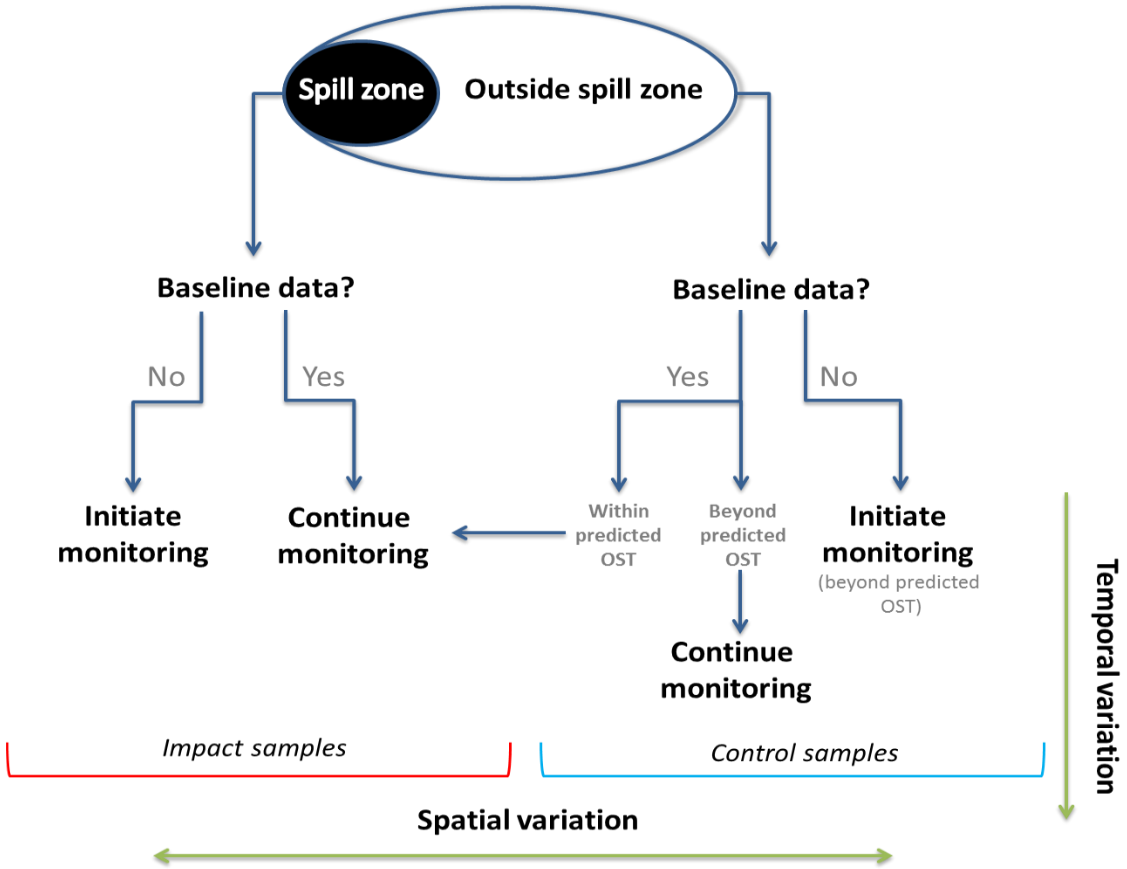

Figure 4 – Monitoring site selection process

6.3.4 Baseline data

Where baseline (i.e. “before”) data are incorporated into the monitoring program design, the monitoring program should undertake monitoring in accordance with the baseline methodology and design (i.e. sites) to minimise variability due to sampling methodology.

Baseline data for a monitoring parameter collected using a different methodology than that used during SMP implementation may lead to variability in the data due to the differing methodologies, potentially resulting in a less powerful statistical analysis. Where practicable, baseline and post-impact data should be collected using the same methods.

Given the uncertainty associated with the nature and scale of oil spills, having an adequate baseline data set prior to the spill is prohibitively expensive in relation to the nature and scale of the environmental risk. Where suitable baseline data are not available, TEO will prioritise collecting pre-impact data from locations that lie within the spill trajectory to serve as pre-impact data. This approach provides useful baseline data for use in statistical analyses while avoiding the need for extensive and costly baseline data collection.

6.3.5 Statistical errors and power

TEO expects that statistical tests may be applied during the analysis of scientific monitoring data. When undertaking a statistical test and making a decision to either reject or retain the null hypothesis, there are four possible outcomes, two of which are correct and two of which are incorrect (Table 8); discussions of the outcomes of a statistical tests used for ecological applications can be found in Underwood (1997) and Quinn and Keough (2002). Note that Type I and Type II statistical errors should not be confused with Type I (operational) and Type II (scientific) monitoring.

Table 8 – Logical outcomes of a statistical test (after Underwood 1997)

		Null hypothesis is actually:	
		True	**False**
Outcome of statistical test	**Reject null hypothesis**	Type I error occurs with probability of α chosen by statistical analyst	Correct conclusion – false null hypothesis is rejected
	Retain null hypothesis	Correct conclusion – null hypothesis is retained	Type II error occurs, determined by β, which may be estimated and controlled by monitoring program design and statistical analysis

6.3.5.1 Type I errors

Type I errors occur when the null hypothesis is rejected based on a statistical test when it is actually true (often called a “false positive”). The Type I error rate is usually controlled during the statistical analysis by setting the significance level (α); by convention α is typically set at 0.05 for many ecological studies. If a 0.05 level of significance is considered acceptable, there is a 1 in 20 (or less) probability of falsely rejecting the null hypothesis.

Increasing α will increase the statistical power of a test, however there will be a corresponding increase in the Type I error rate. Careful consideration should be given prior to increasing α in an effort to increase statistical power. Other factors, such as increasing the number of samples or increasing the effect size, should be considered prior to increasing α. Refer to Section 8.3.5.2 for further consideration of statistical power.

6.3.5.2 Type II errors

Type II errors occur when the null hypothesis is actually false, however the statistical test does not reject the null hypothesis. The Type II error rate (denoted as β) is a component of the power of a statistical test (equal to 1 – β); the more powerful a test is, the less likely a Type II error is. The Type II error rate is not controlled directly by the statistical analysis, rather it is a function of several factors:

- Sample size – this affects the precision of the estimates of the mean and the variability of a given parameter. More samples generally means a more precise estimate (i.e. smaller) of the variance in a parameter, leading to increased statistical power. However, increasing sample size to reduce variance is subject to diminishing returns, reaching a point where the cost of additional sampling exceeds the benefits of increased statistical power.
- Effect size – the effect size is selected by the analyst. Larger effects are easier to detect (e.g. a 50% reduction in seagrass per cent cover is easier to detect statistically compared to a 10% reduction in per cent cover).
- Significance level – refer to Section 8.3.5.1 for a discussion of α and its effect on statistical power.

Statistical power is equal to 1 – β. A power of ≥0.8 (i.e. β is ≥ 0.2) has been suggested by Cohen (1992) as desirable and is often used in ecological applications; however the consequences of a Type II error should be considered when determining an acceptable level of power. Statistical power can be determined by undertaking a power analysis. The power of a statistical analysis can be assessed in two ways:

- A priori: a priori power analysis is done prior to commencing a sampling program; typically, it is done to estimate how many samples are required to achieve a given power. A priori power analysis typically requires information on the parameter of interest (typically population means and standard deviations) and the effect site. Preliminary sampling or other previously collected data (such as that collected during OMP implementation) is used to provide information on the parameters of interest. Where practicable, a priori power analysis should be carried out to inform the design of SMP monitoring programs.
- Post hoc: post hoc power analysis is done after sample collection and data analysis and may be used to determine the likelihood that a Type II error has been made during the test. If post hoc power analysis indicates that your test isn’t sufficiently powerful, it is too late to do anything about it.

Consideration should be given to statistical power when developing a monitoring program, along with a clear statement of the statistical hypotheses being tested. Calculations for determining power vary between statistical analyses; refer to relevant statistical texts or software packages for information on determining power.

6.3.5.3 Replication

Replication is a key consideration in increasing the power (i.e. reducing the likelihood of a type II error) of statistical tests, as replication increases the precision of the estimate of the variability in the parameter being measured. Replication should be at an appropriate scale, both spatially and temporally; replication at the wrong scale (often referred to a “pseudo-replication”) is a common flaw in biological experiments and monitoring programs which incorporate replication at the wrong scale. Careful consideration of the hypotheses and the scale of replication should be made during the design of SMPs to avoid replication at an inappropriate scale.

For example, if a spill has been identified as potentially impacting seagrasses a potential hypothesis and null hypothesis could be:

- Hypothesis: The per cent cover of seagrass meadows exposed to spilled oil is significantly lower than the per cent cover of unexposed meadows
- Null hypothesis: The per cent cover of seagrass meadows exposed to spilled oil is not significantly lower than the per cent cover of unexposed meadows.

If, for example, data were collected to test this hypothesis by measuring per cent cover from one seagrass meadow exposed to oil and one not exposed by estimating per cent cover from replicate photo quadrats within each meadow, the data will not be suitable to test the stated hypotheses. This is because the scale of replication (i.e. within a meadow) is not the scale at which the hypothesis and null hypothesis are testable statements (i.e. at the scale of meadows). In this situation, the scale of replication should be at that of meadows (i.e. multiple meadows exposed to hydrocarbon should be sampled). Note that this pseudo-replicated example can still be used to draw a valid inference about the differences in per cent cover between the exposed and unexposed meadows, however extending this inference more broadly to other meadows is flawed.

Assistance should be sought from suitably qualified and experienced marine scientists when designing and implementing SMPs to avoid replication at inappropriate scales.

7 Data Management

All data collected during implementation of OMPs and SMPs will be stored digitally on TEO's network drive facilities, which are routinely backed up to independent storage. Note that field observations may require transcription or scanning of hard copy documentation into digital format. Storage of data on the TEO network is secure. OSMP data will be retained on the network or on backup drives for a minimum of five years.

The storage of data on the TEO network will facilitate archiving and retrieval of OMP and SMP data. Metadata summaries will be developed for data sets to assist in data searching and identification (Section 9.1).

Documents generated during implementation of operational and scientific monitoring will be managed in accordance with TEO's existing document management system, which incorporates unique document numbers, document updating and review, version / revision control and document ownership.

TEO's data management is routinely communicated to TEO staff during their day to day work, as well as during new employee inductions. TEO will provide advice to third parties (e.g. OSMP service providers) on data management as needed.

7.1 Metadata

Metadata are logically structured summary data set that facilitates the identification, storage and retrieval of a more extensive data set (i.e. metadata are "data about data"). TEO will develop and maintain metadata summaries for all data sets collected during the implementation of OMPs and SMPs.

Metadata summaries will consider guidance material such as the Dublin Core and the Darwin Core. Metadata summaries will include the following as a minimum:

- Title
- Creator
- Subject
- Description
- Date
- Type
- Format
- Location
- Spatial extent.

7.2 Data analysis

All data analysis should be made on copies of original data; original data should not be altered during the analysis. Additional details on suggested data analysis and associated reporting is provided in specific OMPs and SMPs.

7.3 Chain of custody

A clear chain of custody should be maintained at all times during the collection and management of samples and data. This chain of custody should clearly state:

- When the samples / data were collected
- Who collected the samples / data
- What are the intended purposes / required analytes for the samples / data

The chain of custody documentation should be updated whenever samples or data change hands (e.g. field samples given to courier, courier relinquishing samples to analytical laboratories, animal carcasses provided to wildlife agencies). Copies of the chain of custody will be maintained by TEO on the TEO network.

7.4 Sample quality control

7.4.1 Replicates, blanks and spike recovery

Where analytical samples are being collected, consideration should be given to collecting replicate samples within sites. Replicates may include intra- and inter-laboratory duplicates; such duplicates should be labelled in a way that the analytical laboratories are unable to determine which samples are primary samples and which are duplicates. A discussion on general methods and considerations for water and sediment sampling can be found in Manual of standard operating procedures for environmental monitoring against the Cockburn Sound Environmental Quality Criteria (2003 - 2004) (Environmental Protection Authority 2005).

To check the potential contamination of samples, the following blanks should be prepared:

- field blanks (check for contamination when collecting the sample): blank sample matrix (e.g. acid washed sand) in sealed glassware that is opened and exposed to the sampling environment and the accompanies samples
- transport/trip blanks: blank sample matrix (e.g. acid washed sand) in sealed glassware that accompanies the empty glassware and samples while remaining sealed at all times
- rinsate blanks: blank water matrix (e.g. distilled water) that is used to rinse cleaned sampling equipment, collected and analysed
- spike recovery: typically done by analytical laboratories and reported as part of laboratory quality reporting.

Discuss the requirements for blanks with analytical laboratories, which can provide material and glassware for blanks.

Data analysis and reporting should provide an assessment of quality control samples, such as inter- and intra-laboratory duplicates (e.g. by calculating relative per cent differences (RPD) values, spike recovery percentages).

7.4.2 Visual observations

SMPs that rely on visual surveys made by observers (e.g. aerial surveys for cetaceans, visual surveys for birds), or potentially subjective assessments of images (e.g. benthic habitat classification from imagery), steps should be taken to ensure consistency between observations (Thompson and Mapstone 1997). This can include measures such as:

- comparisons of independent observations of the same fauna / imagery
- training of observers for consistency
- review of observation data by subject matter experts
- maintaining consistency between observers.

8 Roles and Responsibilities

Implementation of the OMPs and SMPs requires a range of roles, each of which has responsibilities. Specific roles and responsibilities are discussed in each of the OMPs and SMPs; a summary of roles and responsibilities is provided below in Table 9. A description of the roles and responsibilities of provided below.

The numbers of personnel to fulfil the roles and responsibilities will be a function of the nature and scale of the spill. TEO maintains capacity to respond to the spill scenarios identified in the hydrocarbon spill risk assessments.

All personnel are responsible for implementing safe work practices in accordance with TEO's Health, Safety and Environment Policy and the supporting management system.

All field staff should be suitably qualified and experienced to competently undertake OMPs and SMPs. This may include tertiary qualifications, safe operation of vehicles and equipment etc., and will depend on the nature of the monitoring works being undertaken.

8.1 Incident management team

The IMT structure is described in the OSCP / OPEP. In relation to this OSMP, the IMT are responsible for:

- Determining the level of a spill
- Determining whether the initiation criteria and termination criteria for OMPs and SMP have been met
- Initiating and terminating OMPs and SMPs as required
- Documenting communications between IMT and field personnel
- Facilitating the provision of information to third parties such as spill modelling service providers
- Reviewing information provided by OMPs to inform spill response operations.

8.2 Spill observers

Spill observers are responsible for:

- Undertaking operational observations on the nature, location and extent of spilled oil
- Completing required reporting described in OMP01
- Undertaking trajectory assessments of spilled oil
- Providing information on trajectory assessments to the IMT
- Providing information from field observations to the IMT.

8.3 Modelling personnel

Modelling personnel provide numerical modelling outputs in the event of a spill on the trajectory and weathering of a spill. Modelling personnel are responsible for:

- Undertaking numerical modelling assessment of spill trajectory and oil weathering
- Providing information to the IMT.

8.4 Senior marine scientists

Senior marine scientists are responsible for:

- Providing high level scientific guidance to the IMT and field personnel on the design and implementation of OMPs and SMPs
- Assist the IMT in the management of response service providers (e.g. analytical laboratories)
- Provide support to field personnel on the implementation of OMPs and SMPs
- Facilitate the analysis and interpretation of monitoring results
- Develop metadata summaries for data sets.

8.5 Marine scientists

Marine scientists are responsible for:

- Undertaking field works as required for all OMPs and SMPs as required under the direction of a Senior Marine Scientist
- Completing all documentation as required.

8.6 Environmental management agency staff

Environmental management agency staff may include local, state and federal staff responsible for the management of the natural environment. This may include delegates of management agencies that have particular skills, such as veterinary staff. Environmental management agency staff are responsible for:

- Assisting in the collection and assessment of wildlife carcasses recovered during the spill.

8.7 Commercial fishers

Commercial fishers are responsible for:

- Assisting in the implementation of SMP-07 by providing samples of commercially caught fish for sampling and sensory analysis.

8.8 Sensory analysts

Sensory analysts are responsible for:

- Undertaking sensory perception testing for hydrocarbon taint in fish.

Table 9 – OMP and SMP roles

Role	OMPs					SMPs						
	OMP01	OMP02	OMP03	OMP04	OMP05	SMP01	SMP02	SMP03	SMP04	SMP05	SMP06	SMP07
Spill observers	✓	✓	×	×	×	×	×	×	×	×	×	×
Modelling personnel	✓	✓	×	×	×	×	×	×	×	×	×	×
Senior marine scientists	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Marine scientists	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Environmental management agency staff	×	×	×	✓	×	×	×	×	×	×	✓	×
Commercial Fishers	×	×	×	×	×	×	×	×	×	×	×	✓
Sensory analysts	×	×	×	×	×	×	×	×	×	×	×	✓

9 Operational Readiness

TEO's model of maintaining a response capability utilises the following:

- TEO resources
- Australian Marine Oil Spill Centre (AMOSC) contract for provision of services in the event of a spill, including AMOSC equipment and resources.
- Operational and scientific monitoring specialist consultancies with which Memoranda of Understanding have been reached or the provision of scientific services.
- Support from the AMSA and the DoT for vessel-based spills in Commonwealth and State waters respectively.

9.1 Personnel and equipment

TEO will resource the IMT using internal resources.

TEO maintains a series of Memoranda of Understanding with scientific service providers. These service providers have been assessed as to their ability to support the implementation of OMPs and SMPs, with the array of service providers affording a "defence in depth". The MoU's outline the services that area agreed to be provided, and include:

- Suitably qualified scientists (including appropriate subcontractors) to implement Operational and Scientific monitoring at approval locations in accordance with TEO oil pollution response arrangements
  - In the event of a spill, implement operational and scientific monitoring plans – deploy teams to collect environmental monitoring data and produce reports documenting the analysis and interpretation of monitoring data.
- Office based data management and reporting support by suitably qualified scientists

Equipment required to implement OMPs and SMPs will be sourced primarily by scientific service providers, which will also facilitate laboratory analysis of samples using NATA accredited laboratories.

Logistical support, such as transportation to and from the field, vessels and aircraft will be provided by TEO. TEO has existing arrangements in place with couriers, vessel and aircraft providers in the Cliff Head region. The providers are listed in the Cliff Head OSCP/OPEP and (Appendix D).

9.2 Mobilisation

Mobilisation of resources to implement operational and scientific monitoring will commence with the decision by the IMT to implement monitoring. Once this decision has been made for a given OMP / SMP, the IMT will contact service providers as required to meet the requirements of the OMP / SMP. Contact details for service providers are outlined in Appendix D.

TEO will, in conjunction with service providers, arrange for the mobilisation of resources to site.

10 References

Asia-Pacific Applied Sciences Association (2017). Cliff Head Field: Quantitative Oil Spill Exposure Modelling. Asia-Pacific Applied Science Associates.

Australian Maritime Safety Authority, 2003. Oil spill monitoring handbook. Australian Maritime Safety Authority, Canberra.

Australian Maritime Safety Authority, 2014. National plan for maritime environmental emergencies. Australian Maritime Safety Authority, Canberra.

Cohen, J., 1992. A power primer. Psychological Bulletin 112: 155.

Department of Fisheries, 2012. The Houtman Abrolhos Islands management plan (Fisheries Management Paper No. 260), Fisheries Management Paper. Department of Fisheries, Perth.

Department of Sustainability, Environment, Water, Population and Communities, 2012. Marine bioregional plan for the South-west Marine Region: prepared under the Environment Protection and Biodiversity Conservation Act 1999. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Environmental Protection Authority, 2005. Manual of standard operating procedures for environmental monitoring against the Cockburn Sound Environmental Quality Criteria (2003 - 2004) (Environmental Protection Authority Report No. 21). Environmental Protection Authority, Perth.

MacArthur, L., Hyndes, G., Babcock, R., 2007. Western rock lobster in ecosystem processes of south-western Australia (Report No. 2007-12). Department of the Environment, Water, Heritage and the Arts, Canberra.

McClatchie, S., Middleton, J., Pattiaratchi, C., Currie, D., Kendrick, G. (Eds.), 2006. The south-west marine region: Ecosystems and key species groups. Department of the Environment and Water Resources, Canberra.

Quinn, G.P., Keough, M.J., 2002. Experimental design and data analysis for biologists. Cambridge University Press, Cambridge, UK ; New York.

RPS, 2022. Triangle Energy Cliff Head Spill Modelling Report. 95 pp.

Thompson, A., Mapstone, B., 1997. Observer effects and training in underwater visual surveys of reef fishes. Marine Ecology Progress Series 154: 53–63.

Underwood, A., 1991. The logic of ecological experiments: a case history from studies of the distribution of macro-algae on rocky intertidal shores. Journal of the Marine Biological Association of the United Kingdom 71: 841–866.

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4: 3–15.

Underwood, A.J., 1997. Experiments in ecology: their logical design and interpretation using analysis of variance. Cambridge University Press, Cambridge.

Appendix A Operational Monitoring Plans

Appendix A.1 OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column (4716-HS-H0114-01)

OMP-01 - Oil Distribution Monitoring - Sea Surface, Shorelines and Water Column

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-01

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This OMP-01 - Oil Distribution Monitoring - Sea Surface, Shorelines and Water Column for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

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This OMP-01 - Oil Distribution Monitoring - Sea Surface, Shorelines and Water Column shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This OMP-01 - Oil Distribution Monitoring - Sea Surface, Shorelines and Water Column has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
CHA	Cliff Head Alpha
GPS	Global Positioning System
IMT	Incident Management Team
IMTL	Incident Management Team Lead
NEBA	Net Environmental Benefit Analysis
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and Scientific Monitoring Plan
PPE	Personal Protective Equipment
SMP	Scientific Monitoring Plan
UAV	Unmanned Aerial Vehicle
JHA	Job Hazard Analysis
AMSA	Australian Maritime Safety Authority
PIC	Person in Charge
RPS	RPS
TEO	Triangle Energy (Operations) Pty Ltd

1 Rationale

The rationale and purpose for Operational Monitoring Plan 01 (OMP-01) is to provide regular and daily on-going oil spill surveillance in the event of a hydrocarbon spill. Information collected by this OMP will provide information relating to:

- The type and volume of the spilled hydrocarbon
- The spatial extent of spilled hydrocarbons, including:
  - Surface
  - Entrained
  - Dissolved
- The projected trajectory of the spilled hydrocarbons.

The information collected during implementation of OMP-01 will be used to inform ongoing response operations, as well as the development of scientific monitoring programs (SMPs). Implementation of OMP-01 is a component of the 'Monitor and Evaluate' spill response strategy in the Oil Spill Contingency Plans (OSCPs) / Oil Pollution Emergency Plans (OPEPs) relevant to the Cliff Head project.

OMP-01 is a key component of the monitor and evaluate spill response strategy, which will be implemented in the event of any Level 2 or 3 spill.

1.1 Objectives

The objectives of OMP-01 are:

- To assess the colour, consistency, distribution and trajectory of surface, entrained and dissolved hydrocarbons at sea
- To provide information to other OMPs and SMPs on the nature and scale of hydrocarbon pollution
- To inform the Incident Management Team (IMT) on the distribution and behaviour of spilled hydrocarbon in order to inform response planning and execution
- To identify environmental sensitivities that have been, or are at risk of being, affected by spilled hydrocarbons to inform design of SMPs (including pre-exposure data collection).

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of this OMP, the following inputs will be required from the Oil Spill Contingency Plan (OSCP) / Oil Pollution Emergency Plan (OPEP):

- Release location
- Release time
- Hydrocarbon type (either vessel fuel or Cliff Head crude)
- Estimated volume of spilled hydrocarbon.

2.2 Outputs to other plans

The information obtained during this OMP is used in the following other plans:

- All other OMPs
- All other SMPs
- OSCP / OPEP, including Net Environmental Benefit Analysis (NEBA).

2.3 Relevant environmental data

Existing environmental data relevant to this OMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.4 Initiation criteria

The initiation criteria for implementation of OMP-01 comprise:

- Level 2 or 3 hydrocarbon spill (as determined by OSCP / OPEP).

2.5 Termination criteria

The termination criteria for this OMP comprise:

- Confirmation that source is controlled

AND

- The incident response has been terminated by the IMT

OR

- The information acquired by implementation of this OMP no longer informs decision making by the IMT.

3 Methodology

3.1 Monitoring strategy

OMP-01 is intended to provide the following information on spilled hydrocarbons:

- The location and spatial extent of the spilled hydrocarbons, including information on the nature of the hydrocarbons such as colour, per cent cover, thickness etc.
- The phases of the spilled hydrocarbons (i.e. surface, entrained and dissolved)
- Changes in the spilled hydrocarbons over time (i.e. weathering / evaporation)
- The trajectory of the spilled hydrocarbon
- A preliminary assessment of the environmental receptors that have been exposed to, or at risk of being exposed to, spilled hydrocarbons.

OMP-01 will use a combination of aerial and vessel-based surveys to collect surveillance data to provide an indication of the type of oil, condition and extent of weathering.

The monitoring strategies described in Section 5.2 may all be informed by an understanding of the metocean conditions at the spill location. Local metocean conditions can be determined by observers on site, and can also be obtained from (including forecasts):

- Bureau of Meteorology: http://www.bom.gov.au/
- Integrated Marine Observing System: http://www.imos.org.au/

3.2 Sampling design

3.2.1 Hydrocarbon spill surveillance

3.2.1.1 Aerial surveillance

Aerial surveys may utilise observers on rotary or fixed wing aircraft to monitor surface slicks or entrained hydrocarbons in surface waters where visibility is good.

UAVs may be considered as an aerial platform for spill observations; particular attention should be paid to safety if operating UAVs concurrently with manned aircraft.

As with observations from vessels, trained observers will visually detect hydrocarbons and record the location and character. The colour and optical effects generated by surface films indicate the local concentration of hydrocarbon that is present. For consistency over time and among observers, these should be judged using standardised appearance codes, such as those outlined in the Bonn Agreement (Table 1).

Aerial surveillance of hydrocarbon spills in shallow coastal waters should be mindful of benthic habitats such as seagrass meadows and reefs, which appear as dark patches. These may be confused as patches of floating or entrained oil by an aerial observer.

Aerial observation should be reported using the TEO Aerial Surveillance Form (Appendix A). Refer to the guidance material outlined in Section 5.2 and Appendix B for resources to assist in identification and description of hydrocarbons on or in water.

3.2.1.2 Vessel surveillance

Vessels will be used to undertake spill surveillance, with vessels mobilised through existing service providers either from vessels on site, from Port Denison (Dongara) or Geraldton. The nearest mainland port to the Cliff Head Alpha platform is Port Denison, which is located ~12 NM to the north-north-west of the platform.

The hydrocarbons observed should be assessed in accordance with the Bonn Agreement appearance codes (Table 1). AMSA's Identification of Oil on Water Aerial Observation and Identification Guide (AMSA 2014; Table 1) provides applicable guidance on information gathering and data collection during hydrocarbon spill events. Observations are typically best made from a high vantage point on the vessel, such as the bridge or flybridge.

Note that vessels are constrained in their ability to detect hydrocarbons given the relatively small area that can be observed when compared to aerial surveillance. This can be mitigated by mobilising multiple vessels to undertake visual observation, particularly where aerial surveillance is not available (e.g. immediately following a spill prior to mobilisation of aerial platforms). If the spilled volume or initial monitoring suggests that vessel surveillance may be inadequate to monitor spilled hydrocarbon, aerial surveillance should be implemented 5.2.1.1.

Trained observers will visually detect hydrocarbons and record its location and character. The colour and optical effects generated by surface films indicate the local concentration of hydrocarbon that is present. For consistency over time and among observers, these should be judged using standardised appearance codes, such as those outlined in the Bonn Agreement (Bonn Agreement 2011, 2009). The Bonn Agreement defines five appearance codes, each representing a range of thicknesses, with no sharp delineation (i.e. one optical effect becomes more diffuse as the other strengthens; Table 1). Refer to the guidance material outlined in Section 7.2 and Appendix B for resources to assist in identification and description of hydrocarbons on or in water.

Table 1 – Bonn Agreement appearance codes and the corresponding estimate of oil quantities

Code	Appearance	Approximate Thickness (µm) (Litres per km^2)
1	Sheen (silvery/grey)	0.04 to 0.30 µm (40–300)
2	Rainbow	0.30 to 5.0 µm (300–5000)
3	Metallic	5.0 to 50 µm (5000–50,000)
4	Discontinuous True Oil Colour	50 to 200 µm (50,000–200,000)
5	Continuous True Oil Colour	200 to > 200 µm (200,000 to >200,000)

Vessel based observers should also routinely monitor the local metocean conditions in the spill area, including:

- Sea state
- Current speed
- Wind speed

Metocean conditions are of use in hydrocarbon trajectory assessments and should be routinely documented during vessel surveillance and reported to the IMT.

3.2.1.3 Buoys and drogues

Tracking buoys and drogues can be deployed from aircraft and vessels to drift with the spiled hydrocarbons. They can then be monitored directly to indicate the location of the spill. Tracking buoys and drogues are advantageous over direct spill monitoring in that they are generally more easily observed than the spilled hydrocarbon, particularly as surface slicks disperse.

Satellite tracking buoys provide remote telemetered data and do not need to be monitored visually by vessels or aircraft. Non-telemetered buoys must be tracked visually, either by vessels or aircraft; non-telemetered buoys should be highly visible. Radar tracking of buoys is not recommended as a surface large enough to produce a reliable radar return may be unduly affected by wind.

Drogues are similar to tracking buoys, but differ in that a high drag component is tethered to the buoy, with the length of the tethered determining the depth at which the high drag component is situated. Drogues are used to track subsurface currents; as such they may be of use in informing the movement of entrained and dissolved oil at depth.

Tracking buoys are particularly useful if deployed at the release location immediately following the release. If buoys cannot be deployed immediately, the use of tracking buoys should prioritise large patches of spilled oil, or patches of oil that are considered to pose a particular risk to an environmental sensitivity (e.g. oil in proximity to sea lion haul outs).

3.2.1.4 Hydrocarbon trajectory assessment

Hydrocarbon trajectory assessments can be used to plan spill response activities and identify environmental receptors at risk of exposure. Note that trajectory assessments are reliant on the accuracy of the data used on the assessment. Trajectory assessments are subject to uncertainty, which should be considered when using information from spill trajectory assessments.

Trajectory assessments are iterative and should be conducted on an ongoing basis during the spill response.

3.2.1.5 Field assessment

The trajectory of spilled hydrocarbons in the field can be assessed based on the prevailing metocean conditions. Field assessments of hydrocarbon trajectory are based on known locations of spilled hydrocarbons (surface slicks or entrained oil as determined in Section 5.2.1).

Field assessments of hydrocarbon trajectory are made based on the following:

- Current vector – heading (degrees) and velocity (m/s)
- Wind vector – heading (degrees) and velocity (m/s)

The following method can be used to determine the hydrocarbon trajectory in the field:

- Determine the current vector (e.g. by tracking current drogues)
  - Current direction (i.e. the direction the current is flowing to) in degrees
  - Current velocity in metres per second
- Determine the scale wind vector (e.g. meteorological observations)
  - Wind direction (IMPORTANT – this is the direction the wind is blowing to, not the direction the wind is blowing from as is typically reported) in degrees
  - Wind velocity in metres per second multiplied by 0.03 (i.e. 3% of the wind velocity)
- Add the current vector and the wind vector using vector addition (graphical and mathematical methods are available to undertake this) to determine the spill trajectory vector.

Once the spill trajectory has been determined, the velocity component may be converted from m/s to km/h to aid in practical application by multiplying the speed in m/s by 3.6.

Note that vector units must be the same (angular units should be in degrees, velocity units should be equivalent i.e. both vectors are in common units such as metres per second or kilometres per hour).

3.2.1.6 Spill modelling

The trajectory of spiled hydrocarbons can be modelled using computational numerical modelling techniques. TEO has access to numerical spill modelling services on a 24 hr basis through the service agreement in place with the Australian Marine Oil Spill Centre (AMOSC), which utilise RPS to provide hydrocarbon modelling services. The service uses the OILMAP software package, which models the fate of surface, entrained and dissolved oil.

Inputs required for accurate numerical modelling include:

- Metocean conditions (wind speed and direction, current speed and direction, water temperature)
- Release location
- Release volume
- Hydrocarbon characteristics.

Note that RPS has previously modelled the credible hydrocarbon release scenarios for the Cliff Head project and has information on the credible hydrocarbon characteristics (RPS 2022 and RPS APASA 2017).

Spill trajectory modelling can be refined based on the information obtained during hydrocarbon spill surveillance (spill location, metocean conditions, weathering etc.).

Outputs from spill modelling include the projected wreathing of the spilled hydrocarbon and the trajectory of the spill, including estimated times to contact. These outputs inform decision making by the IMT and the design and implementation of OMPs and SMPs.

3.3 Shoreline monitoring

Where hydrocarbon spill surveillance or trajectory assessment indicates that shoreline contact has occurred or is likely to occur, OMP-03 – Shoreline Assessment (4716-HS-H0114-03) and SMP-03 – Scientific Monitoring of Shoreline and Intertidal Benthos (4716-HS-H0114-13) should be implemented.

3.4 Data management

3.4.1 Field data management

Observations of spilled hydrocarbons will be recorded on Aerial Surveillance Forms (Appendix A) during monitoring and communicated to IMT via communications channels (telephone, email, radio). The IMT will document all relevant information at the incident control centre as per the incident communications arrangements described in the OSCP / OPEP.

3.4.2 Office data management

All communications with the field team and the IMT will be recorded. All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

Following the termination of the incident response, all data collated by the IMT should be catalogued and archived and a metadata summary developed for all data.

3.4.3 Data analysis

Data provided to the IMT will be assessed by the IMTL and the onsite PIC. Information from this OMP will be used to inform the decision making on response strategies.

4 Reporting

4.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly notify the IMT and seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

4.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other OMPs and SMPs
- Reports detailing the extent of the spill based on Aerial Surveillance methods containing estimates of quantity, type, percentage coverage etc. throughout the surveillance program. Reports should contain descriptive statistics of data collected. Reports should document whether
  - the termination criteria for the OMP have been reached
  - SMP initiation criteria have been reached.

The concentration of hydrocarbons in water samples is used as a trigger for the initiation of SMP-01 and SMP-02; refer to Section 4.2 for the threshold values for hydrocarbons in water and sediment. All analytical results should be compared against the threshold values immediately after receipt to enable SMP-01 and SMP-02 to be implemented in a timely manner.

5 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this OMP in the field.

5.1 Personnel

In addition to the generic staff requirements described in the Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (OSMP) (4716-HS-H0114), staff required to implement OMP-01 should hold the following qualifications and competencies:

- Spill observer(s) – to monitor and evaluate the hydrocarbon spill
- Trajectory assessor(s) – to determine the trajectory of the spilled hydrocarbon
- Senior marine scientist – to assist in defining the monitoring program design
- Marine scientist(s) – to undertake OMP under the direction of senior marine scientist
- Vessel and / or aircraft crews.

Note that, where practicable, personnel that have multiple competencies should fulfil more than one role to increase the efficiency of the OMP implementation.

All personnel conducting field surveys should be competent in and/or experienced in aerial and vessel based hydrocarbon spill surveillance. All personnel undertaking hydrocarbon spill trajectory assessments should be experienced in the techniques applied during the trajectory assessment.

Hydrocarbon surveillance may require vessels, aircraft or vehicles and therefore, additional team members and qualifications required (e.g. offshore medical) where practicable. However, given the environmental emergency situation in which OMP-01 would be implemented, incident controllers should use good judgement when deploying teams to the field.

5.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for OMP-01:

- Vehicles for accessing survey areas; may include vessels, aircraft or unmanned aerial vehicles (UAV) suitable for use as observation platforms, as required
- Video cameras, storage media and batteries (with spares)
- Digital still and video cameras (optionally with global positioning system (GPS)), storage media and batteries (with spares)
- GPS
- Buoys and drogues (with satellite tracking where possible)
- TEO Aerial Surveillance Form (Appendix A)
- Guidance material on the identification of spiled hydrocarbons, which may include:
  - Identification of oil on water aerial observation and identification guide (Australian Maritime Safety Authority 2020)
  - Aerial observation of marine oil spills (International Tanker Owners Pollution Federation 2011)
  - Bonn Agreement aerial operations handbook (Bonn Agreement 2009)
  - Bonn Agreement oil appearance code photo atlas (Bonn Agreement 2011).

5.2.1 Preparation

The following activities will need to be undertaken, to ensure equipment is in working order, prior to mobilisation to the field:

- Confirm equipment resources and availability
- Confirm all GPS units and digital cameras are in good working order and that sufficient spare batteries and memory cards have been obtained
- Check field laptops, ensuring that they have batteries, power cable, licenses, logins and are functional
- Check video cameras, ensuring that they have sufficient batteries, storage media, power cables, and are functional
- Arrange transport of equipment to mobilisation point.

5.3 Logistics

Upon notification that OMP-01 has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase:

- Assemble competent field team (refer to Section 5.1), including required personal protective equipment (PPE)
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel, aircraft or vehicle(s) for monitoring operations
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 4)
- Confirm survey sampling plan and continually update as new situational awareness information becomes available
- Develop and implement JHA and TEO Oil health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure field consumables and equipment (refer to Section 5.2).

6 References

Australian Maritime Safety Authority, 2014. Identification of oil on water aerial observation and identification guide. Australian Maritime Safety Authority, Canberra.

Bonn Agreement, 2009. *Bonn Agreement aerial operations handbook*. Bonn Agreement Secretariat, London.

Bonn Agreement, 2011. *Bonn Agreement oil appearance code photo atlas*. Bonn Agreement Secretariat, London.

Department of the Environment, Water, Heritage and the Arts, 2009. National Assessment Guidelines for Dredging. Department of the Environment, Water, Heritage and the Arts, Canberra.

International Tanker Owners Pollution Federation, 2011. Aerial observation of marine oil spills (Technical Information Paper No. 1). International Tanker Owners Pollution Federation Limited, London.

RPS (2022). Triangle Energy Cliff Head Oil Spill Modelling. Report Prepared for Prepared for Triangle Energy (Operations) Pty Ltd.

RPS APASA (2017). ROC Oil - Cliff Head Oil Spill Risk Assessment – Revision. Prepared for ROC Oil (Wa) Pty Ltd.

Appendix A. Aerial Surveillance Form

Aerial SURVEILLANCE FORM		
INCIDENT:		REF. NO:
DATE:	TIME:	(24HR)
ATTACHMENTS:	NO. OF PAGES:	

FROM :	OBSERVER'S NAME:	POSITION:
	AIRCRAFT:	PILOT NAME:

AREA/REGION:		TIME:		(24hr)
SLICK POSITION:	LATITUDE:	LONGITUDE:		
	OTHER:			
SLICK DESCRIPTION:	SLICK LENGTH: m	SLICK WIDTH: m	AREA:	km^2
	PERCENTAGE COVER / COLOUR	CLEAN SURFACE		%
		SILVER SHEEN		%
		RAINBOW / IRIDESCENCE		%
		DULL COLOURS		%
		DARK BROWN / BLACK		%
		LIGHT BROWN (EMULSION)		%
	OTHER DESCRIPTION / NOTES			
MOVEMENT / BEHAVIOUR:				
VISIBILITY:	WEATHER	CLOUD COVER / HEIGHT		
OTHER NOTES:				
AREA / REGION:		TIME:		(24 HR)
SLICK POSITION:	LATITUDE	LONGITUDE		
	OTHER			
SLICK DESCRIPTION:	SLICK LENGTH m	SLICK WIDTH m	AREA	km^2
	PERCENTAGE COVER / COLOUR	CLEAN SURFACE		%
		SILVER SHEEN		%
		RAINBOW / IRIDESCENCE		%
		DULL COLOURS		%
		DARK BROWN / BLACK		%
		LIGHT BROWN (EMULSION)		%
	OTHER DESCRIPTION / NOTES:			
MOVEMENT / BEHAVIOUR:				
VISIBILITY:	WEATHER	CLOUD COVER / HEIGHT		

RESOURCE	TYPE/SPECIES	Number	LOCATION	Behaviour /Comment
CETACEANS		Adult ______ Juvenile ___	LAT _______	Direction of movement. Proximity to oil.

		Calf _______	LON _______	Proximity to vessels. Identifying marks* Aversion or other behaviour*
TURTLES		Adult ______ Juvenile ___	LAT _______ LON _______	Direction of movement. Proximity to oil. Proximity to vessels. Aversion or other behaviour*
DUGONGS	-	Adult ______ Juvenile ___ Calf _______	LAT _______ LON _______	Direction of movement. Proximity to oil. Proximity to vessels. Aversion or other behaviour*
SHARKS	WHALE SHARK OTHER		LAT _______ LON _______	Direction of movement. Proximity to oil. Proximity to vessels.
SEA SNAKES			LAT _______ LON _______	Direction of movement. Proximity to oil. Proximity to vessels.
BIRDS			LAT _______ LON _______	Direction of movement. Proximity to oil. Proximity to vessels. In flight/ roosting/ nesting
VESSELS	FISHING/OTHER INDONESIAN / AUSTRALIAN		LAT _______ LON _______	Direction of movement. Proximity to oil. Activity (e.g. Fishing). Size (m length)

Other Details for each Observation Location			
Ambient Conditions at Each Location	Date	**Photographic Record**	Date and time of each photo
	Time		Photo/video clip number
	Weather conditions		Brief description
	Visibility (atmospheric)		Lat and Log of position
	Water turbidity		Direction of photograph

*Requires trained observers

Appendix B. Guideline for Characterising Oil at Sea

Rationale
Monitoring of slick character is needed for planning marine response strategies. Slick area indicates the scale of the response needed. Percentage cover and slick thickness indicate likely efficiency of containment or dispersant methods and may also indicate the likely persistence of the slick.

Methodology		
1	Locate slick as per Guideline M.2.	
	Note: Preferred altitude is 300-500m (1000-1500 feet) for marine surveillance. Aircraft should orientate the observer to about a 30 degree angle.	
2	Determine the area of the slick.	
	2.1	Fly the length of the slick and record the time taken and the aircraft speed (note: 1 knot = 0.5m per second or 1.8 km per hour).
	2.2	Fly the width of the slick and record the time taken and the aircraft speed.
	2.3	Calculate length and width using one of the following the formulae: • Distance (in metres) = Time (seconds) x speed (knots) x 0.5. • Distance (in km) = Time (seconds) x speed (knots) x 1.8
	2.4	Calculate approximate slick area as length x width
	Note that this figure is an approximation of the area covered by all components of the slick including films.	
3	Determine the thickness and distribution of the oil in the slick.	
	3.1	Use the Table of oil colour below to estimate the thickness of the various parts of the slick.
	3.2	Estimate and record the relative proportions (Percentage Cover) of clean water and each colour (or thickness) over the slick area. Use the Percentage Cover Aid in the Figure overpage. Data should be recorded on the Aerial Observation Form (in Appendix A) or similar data sheet.
	3.3	Record other indications of thickness such as a distinct "edge" or a dampening of the water surface "texture" both of which indicate a thick slick.

Oil Colour and Thickness		
Description/ Colour	**Thickness (mm)**	**Volume (m^3/sq km)**
Silvery sheen	0.0001	0.1
Bright bands of rainbow colour	0.0003	0.3
Dull colours seen	0.001	1.0
Yellowish brown slick	0.01	10
Light brown or black slick	0.1	100
Thick dark brown or black slick	1.0	1,000

Percentage Cover

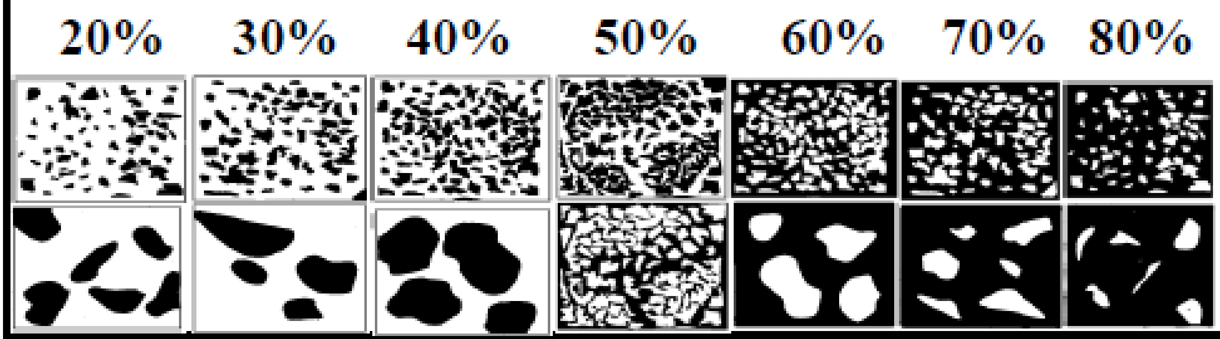

Figure M.3.1

Methodology Continued		
4	If required, estimate volume of oil on the sea surface.	
	4.1	Calculate the area of each colour (thickness) of oil in the slick: $A_c = \%C_c \times A_t$
	4.2	Calculate the volume of oil in each colour by multiplying area by estimated thickness of oil in each colour (see Table on previous page). $V_c = A_c \times T_c$
	4.3	Calculate total Volume of oil by adding the volumes for each colour.
		The Table provided below can be used to calculate volumes.
	Note: Polaroid sunglasses or camera lens filters should be avoided as these tend to darken the oil's colours. Reflected glare should be reduced by altering the location of the aircraft (i.e. viewing with the sun behind the observer).	

Description of Oil Thickness/ Colour	% Cover of Colour $\%C_c$	Area of each Colour	Thickness of Colour T_c	Volume of the Slick V_c
Silvery sheen			0.0001mm	
Bright bands/rainbow			0.0003mm	
Dull colours			0.001mm	
Yellowish brown			0.01mm	
Light brown or black			0.1mm	
Thick dark brown/black			1.0mm	
Total				
	% Cover of Slick $\%C_t$	*Area of oil in Slick (A_t)*	*Volume/ Sq Km can also be used*	*Total Volume of Oil in Slick*

Appendix A.2 OMP-02 – Oil Character and Fate Modelling (4716 HS H0114¬02)

OMP-02 - Oil Character and Fate Modelling

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-02

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This OMP-02 - Oil Character and Fate Modelling for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

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This OMP-02 - Oil Character and Fate Modelling shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This OMP-02 - Oil Character and Fate Modelling has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
AMOSC	Australian Marine Oil Spill Centre
BTEXN	Benzene, toluene, ethylbenzene and xylenes and naphthalene
CHA	Cliff Head Alpha
CoC	Chain of Custody
GPS	Global Positioning System
IMT	Incident Management Team
IMTL	Incident Management Team Lead
JHA	Job Hazard Analysis
MGA	Map Grid of Australia
NATA	National Association of Testing Authorities
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and Scientific Monitoring Plan
OSMT	Oil Spill Management Team
PAH	Polycyclic aromatic hydrocarbon
PIC	Person in Charge
PPE	Personal Protective Equipment
RFU	Raw Fluorometer Units
SMP	Scientific Monitoring Plan
TEO	Triangle Energy (Operations) Pty Ltd
TPH	Total Petroleum Hydrocarbon
TRH	Total Recoverable Hydrocarbons
UAV	Unmanned Aerial Vehicle
USB	Universal Serial Bus

1 Rationale

The rationale and purpose of operational monitoring plan 02 (OMP02) is to provide information on the weathering and fate of spilled hydrocarbons. This information can be used to inform the Incident Management Team (IMT) to aid in the selection, implementation and assessment of response strategies. Information on the weathering and fate of spilled hydrocarbons is also of use in the design and implementation of scientific monitoring plans (SMPs).

The assessment of hydrocarbon character and fate may draw on information from a range of other OPMs and SMPs, including sample collection, laboratory analysis and numerical modelling. The hydrocarbon character and fate assessment should consider the following hydrocarbon phases:

- Surface
- Entrained
- Dissolved
- Stranded.

The information collected during implementation of OMP-02 will be used to inform ongoing response operations (as described in the Oil Spill Contingency Plan (OSCP) / Oil Pollution Emergency Plan (OPEP) relevant to the Cliff Head project), as well as the development of SMPs as required.

1.1 Objectives

The objectives of OMP-02 are to:

- To assess the fate of spilled hydrocarbons (surface, entrained, dissolved and stranded) in water and sediments, and on shorelines
- To provide an assessment of how the spilled hydrocarbon has weathered over time, including estimates of volumes of hydrocarbons in various phases
- To provide information to other OMPs and SMPs on the nature and scale of hydrocarbon pollution
- To inform the Incident Management Team (IMT) on the fate and weathering of spilled hydrocarbon in order to inform response planning and execution.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of this OMP, the following inputs will be required from the Oil Spill Contingency Plan (OSCP) / Oil Pollution Emergency Plan (OPEP):

- Release location
- Release time
- Hydrocarbon type
- Estimated volume of spilled hydrocarbon
- Current and previous distribution of hydrocarbons from the spill based on operational monitoring plan (OMP-01).

2.2 Outputs to other plans

The information obtained during this OMP is used in the following other plans:

- OMP-03 – Shoreline assessment
- OMP-04 – Wildlife impact monitoring
- OMP-05 – Response strategy monitoring
- All SMPs
- OSCP / OPEP, including Net Environmental Benefit Analysis (NEBA).

2.3 Relevant environmental data

Existing environmental data relevant to this OMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.4 Initiation criteria

The initiation criteria for implementation of OMP-02 comprise:

- Level 2 or Level 3 hydrocarbon spill (as determined by OSCP / OPEP).

2.5 Termination criteria

The termination criteria for this OMP comprise:

- Confirmation that source is controlled

AND

- The incident response has been terminated by the IMT

OR

- The information acquired by implementation of this OMP no longer informs decision making by the IMT

OR

- SMP monitoring that superseded this OMP (i.e. SMP-01 and SMP-02) has commenced.

3 Methodology

3.1 Monitoring strategy

Implementation of OMP-02 should be informed by, and ideally implemented concurrently with, OMP-01. SMP-01 and SMP-02 may be triggered pending the results of OMP-02; the methodologies employed in SMP-01 and SMP-02 are consistent with those in OMP-02 to facilitate field sampling.

OMP-02 is intended to provide the following information on spilled hydrocarbons:

- The fate of spilled hydrocarbons (including volume estimates):
  - Surface (i.e. surface slicks)
  - Dissolved
  - Entrained
  - Stranded
- The concentrations of hydrocarbons in water and sediment
- Changes in the spilled hydrocarbons over time (i.e. weathering / evaporation).

Note that OMP-02 is not intended to be a statistically robust monitoring program for quantifying the impacts of hydrocarbons in the marine environment. This is provided in the implementation of SMPs as required; however the data collected in this OMP should be used to inform the design of SMP-01 and SMP-02. As such, quality assurance procedures and quality control samples such as inter-laboratory duplicates, blanks and rinsate samples have been omitted. Such samples are considered within the relevant SMPs, where the standards and rigour of the sampling program is higher in order to meet the objectives of these plans.

3.2 Sampling design

The selection of hydrocarbon, water and sediment sampling sites should be selected based on the known distribution of the hydrocarbon spill, as determined in OMP-01.

3.2.1 Surface / stranded hydrocarbon sampling

Where practicable, samples of spilled hydrocarbons should be collected and analysed during OMP-02 implementation. Hydrocarbons will most easily be sampled where they have formed a surface slick or have stranded on a shoreline.

Hydrocarbon samples should be stored in pre-cleaned glass jars with an appropriate lid, such as Teflon. Liaise with the analytical laboratories to determine sample glassware, storage and handling requirements, along with the volumes required for analysis. In addition to standard PPE outlined in the overarching OSMP (4716-HS-H0114), nitrile gloves should be worn when handling spilled hydrocarbons and discarded after use.

Sampling of surface slicks can be undertaken from vessels in conjunction with the implementation of other OMPs and SMPs, or other elements of this OMP. Surface slicks can be sampled either by directly filling the sample jar from the slick, or by collecting hydrocarbons from surface slicks using sorbents and draining the hydrocarbons into a sample container.

Sampling of shoreline slicks can be undertaken by shore-based personnel (or boat-based where contact with offshore islands has occurred). Shoreline samples can be taken by collecting the stranded hydrocarbon and storing it in a sample jar. Care should be taken to avoid excess sediment being collected.

Hydrocarbon samples should then be analysed for the parameters in Table 1. Discuss the sampling requirements with analytical service providers. Holding times for hydrocarbon samples should also be discussed with analytical laboratories.

Where practicable, replicate samples of surface or stranded hydrocarbons should be collected and analysed, however bear in mind that OMP-02 is not intended to be a statistically robust monitoring program for quantifying the impacts of hydrocarbons in the marine environment.

Table 1 – Parameters for consideration in hydrocarbon analysis

Parameter	Comment
Physical parameters	
Specific gravity / density	At 15 °C
Viscosity	In Centistokes (cSt)
Pour point	In °C
Flash point	In °C
General physical observations	Colour, adhesiveness etc.
Chemical parameters	
Aliphatic / aromatic content	As % of whole oil
Wax content	
Ashphaltenes content	
Distillation profile	Consistent with American Petroleum Institute (API) methods
Total polycyclic aromatic hydrocarbon (PAH) and detailed breakdown by gas chromatography / mass spectroscopy (GC/MS)	PAHs account for significant portion of hydrocarbon toxicity
Water content	As % of whole oil
Volatiles including % loss	As % of whole oil

3.2.2 Water sampling

Where a surface slick is present, a hydrocarbon-free area will need to be created adjacent to the vessel to reduce contamination of sampling equipment as it is lowered through the surface of the water. To do this, a surface free of hydrocarbons should be created. This can be done using a boom deployed from the vessel and surface hydrocarbons will be removed from within via absorbent pads (see Figure 1). While there may still be some trace amounts of hydrocarbons remaining, the majority of floating surface material will be removed via this method, allowing the sampling equipment to be lowered into the water with a reduced risk of contamination.

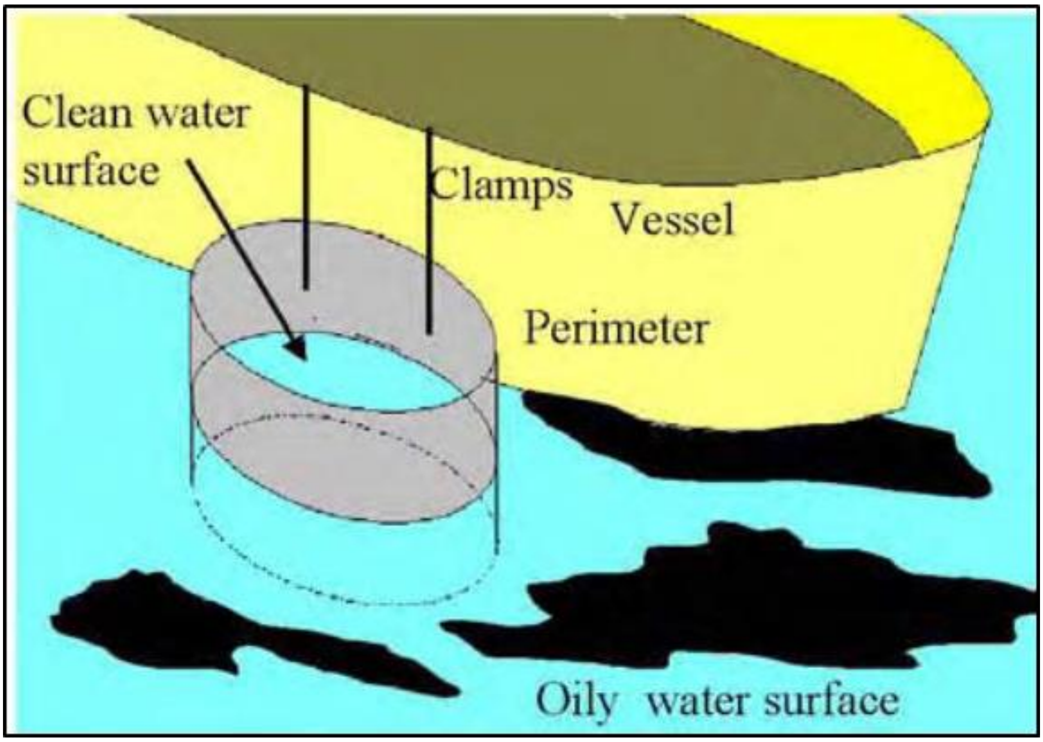

Figure 1 – Example deployment of a bottomless perimeter for clean water sampling

The distribution of hydrocarbons (if present) in the water column will be measured by deploying a fluorometer along with a water quality profiler where practicable. The fluorometer will be deployed in situ initially and the data collected will be used to determine the depths where water quality samples will be collected. If the fluorometer does not indicate hydrocarbons being present in the water column, subsurface water samples should be collected at near surface, the middle of the water column and near the seabed. The water collection sampler will collect samples at depths where the fluorometer has indicated that hydrocarbons are present. Note that care should be taken to avoid sample contamination by a surface slick.

At each location the following protocol will be followed:

(1) Field observations, including, time, location and meteorological conditions, will be recorded on field observation sheets and entered into digital data storage as soon as practicable
(2) Latex gloves to be worn whilst handling water sampling equipment. Gloves should be changed between each water sampling location
(3) Potential anthropogenic contaminants (e.g. sun cream, smoking/smokers, sweat, hydrocarbons from exhaust gases, fuel or cleaning agents etc.) are to be avoided by the personnel in contact with the water sampling equipment The insides of the sample container lids will not come in contact with anything potentially contaminated (such as hands, gloves, work area or vessel). Hands cannot come into contact with the insides or lip of the bucket or sample bottles, the tip of the syringe or the syringe filters
(4) A water sample should be collected using a water sampling device and recovered to the surface
(5) Empty the contents of the water sampler into a clean bucket or volumetric flask (after rinsing the container with sample water three times)
(6) Sample water will be transferred into containers for hydrocarbon analysis. A syringe may be used to transfer the sample water to the sample bottles, but care must be taken that the outside of the syringe does not touch any other surface. The syringe will also need to be rinsed three times with sample water before any sample is transferred. For larger samples, a volumetric measuring cylinder may also be utilised with the same rinsing method
(7) Containers must be filled as full as possible to exclude air and avoid evaporative losses of light hydrocarbons.

After collection of samples at each site, the procedure below will be followed:

- Samples will be labelled according to instructions in Section 3.2.6
- All samples will be kept cool on ice or refrigerated to 4°C until delivery to the laboratory
- The water sampler is decontaminated (e.g. by cleaning with Decon 90 and rinsing with clean seawater) prior to collecting the next sample.

Analytical parameters (with comments) are provided in Table 2. It is important to note that this information should be confirmed with laboratories, as holding times and limits of reporting may vary between service providers.

Sufficient glassware and consumables should be available to collect samples from at least five sites initially, with follow up sites samples as required.

Table 2 – Hydrocarbon parameters in water samples

<table>
<tr><th>Parameter</th><th>Comment</th></tr>
<tr><td>Total recoverable hydrocarbons (TRH)</td><td rowspan="3">Chill to 4 °C with zero head space for storage and transport.
Hold for less than one week.</td></tr>
<tr><td>Benzene, toluene, ethylbenzene and xylenes and naphthalene (BTEXN)</td></tr>
<tr><td>PAH</td></tr>
<tr><td>Ultraviolet fluorometer data, Profile of aromatic hydrocarbons fluorescing through water column. Results will be based on Raw Fluorometer Units (RFUs) until calibration curve can be prepared identifying relationship between RFUs and laboratory data</td><td>Profiling fluorometer can be attached to other water quality profiling instruments (see SMP01)</td></tr>
</table>

3.2.3 Sediment sampling

Where a surface slick is present, a hydrocarbon-free area will need to be created adjacent to the vessel to mitigate contamination of sampling equipment as it is lowered through the surface of the water (as per Section 3.2.2).

Once at the sampling site, the following procedure should be followed:

(1) Confirm with vessel master, crew and scientific personnel that sampling is about to commence
(2) Undertake a task briefing to ensure that all personnel understand their roles and responsibilities
(3) Record field observations, including, time, location and meteorological conditions
(4) Prepare the sediment sampler for use (e.g. ensure that it has been decontaminated, sampler prepared as per manufacturer / work instructions)
(5) Lower the sampler to the seabed, confirm the sample has been collected and retrieve the sampler to the deck
(6) Allow excess water to drain from the sampler, taking care to avoid excessive loss of sediments (particularly fines)
(7) If the sediment sample is not completely intact (e.g. due to incomplete closure of the sampler), the sample is discarded and another taken
(8) A photograph of the sediment sample (including details such as site, date, sample number etc. on a white sheet / clapper board) should be taken prior to filling sample vials
(9) The surface sediments (approximately 2-3 cm) are removed and placed in a mixing bowl, homogenised and then sample containers filled with the required quantity of sediment (refer to guidance from analytical laboratories to required mass / volume)
(10) All sample containers should be pre-labelled, or labelled immediately following collection with indelible marker (Section 3.2.6)
(11) Equipment cleaned, decontaminated and prepared for next sample and excess sediment discharged overboard
(12) Samples should be stored in accordance with the holding instructions from the analytical laboratory (typically ~4 °C either refrigerated or in coolers with ice bricks, in the dark)
(13) Sample details recorded on field data sheet.

Unless sampling in areas where sediments are highly worked (e.g. high energy beaches), hydrocarbon contamination from a spill will be concentrated in the surface sediments. As such, sampling should focus on surface sediments where practicable (approximately 2-3 cm).

Be mindful when filling sample containers to avoid touching the inside of the container or uncapping the containers for any longer than necessary. Pay attention to avoiding potential sources of hydrocarbon contamination such as exhaust fumes, drips from overhead wires or grease covered equipment.

Analytical parameters (with comments) are provided in Table 3 It is important to note that this information should be confirmed with laboratories, as holding times and limits of reporting may vary between service providers.

Sufficient glassware and consumables should be available to collect samples from at least five sites initially, with follow up sites samples as required.

Table 3 – Hydrocarbon parameters in sediment samples

Parameter	Comment
Naphthalene	Chill to 4 °C, zero head space, in the dark for storage and transport. Hold for less than two weeks.
Low molecular weight PAHs	
High molecular weight PAHs	
Total PAHs	
TPH	

3.2.4 Shoreline sampling

Where hydrocarbon spill surveillance or trajectory assessment indicates that shoreline contact has occurred or is likely to occur, OMP-03 – Shoreline Assessment (4716-HS-H0114-03) and SMP-03 – Scientific Monitoring of Shoreline and Intertidal Benthos (4716-HS-H0114-13) should be implemented.

3.2.5 Numerical modelling

Numerical modelling studies can be undertaken to provide an indication of spilled hydrocarbon fate. TEO has access to numerical spill modelling services on a 24 hr basis through the service agreement in place with the Australian Marine Oil Spill Centre (AMOSC), which utilise RPS to provide hydrocarbon modelling services. The service uses the OILMAP software package, which models the fate of surface, entrained and dissolved oil.

Inputs required for accurate numerical modelling include:

- Metocean conditions (wind speed and direction, current speed and direction, water temperature)
- Release location
- Release volume
- Hydrocarbon characteristics (including information on weathered hydrocarbons).

Note that RPS has previously modelled the credible hydrocarbon release scenarios for the Cliff Head project and has information on the credible hydrocarbon characteristics.

Liaison with AMOSC should commence early in the spill response to ensure that appropriate information is collected during the operational response as inputs into numerical modelling studies.

3.2.6 Sample labelling

All analytical samples should be pre-labelled or labelled immediately following sealing of the container with indelible marker. Sample containers will be clearly labelled with the following information as a minimum:

- Unique sample identification (ensure that the sample identification is clearly recorded in the field data sheet). This sample identification should be unique, unambiguous and clearly linked to the sampling site
- Analytical parameter(s)
- Sample collection time and date
- Project specific job number.

3.2.7 Sample storage and transport

Samples must be handled, stored and transported with care to avoid contamination. Samples should be collected and sent to the specified laboratory for analysis in accordance with holding times wherever practicable. Note that non-compliance with holding times and sample storage requirements may invalidate analytical results.

Samples should be packed securely into suitable size coolers using packing material and freezer blocks for delivery to each laboratory. CoC forms should be completed and accompany all analytical samples following collection. Whenever samples change hand (e.g. from field team to courier, from courier to analytical laboratory) the CoC should be updated to reflect this.

3.3 Data management

3.3.1 Field data management

Field observations will be recorded on data sheets during monitoring. Information will be recorded on each data sheet, must include, but is not limited to:

- Date and time of sampling
- Sample site reference code/number
- Water depth(s)
- GPS position
- Sample description
- Numbers of samples
- Metocean conditions
- Person responsible
- Additional comments.

Digital field data (e.g. photographs) should be downloaded as soon as practicable and backed up onto independent storage (e.g. portable hard drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. portable hard drives). All written data sheets should be stored securely. All data in digital format should be transmitted off site for additional data security where practicable (e.g. to TEO Pty Ltd office in West Perth for storage on network drives).

Summaries of samples collected for all locations visited will be included in standard daily field reports from field teams to TEO Pty Ltd.

All field data collection should be communicated to the IMT via communications channels (telephone, email, radio). The IMT will document all relevant information at the incident control centre as per the incident communications arrangements.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to be sealed in the cooler with the samples for transport.

3.3.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All communications with the field team and the IMT will be documented. All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

Following the termination of the incident response, all data collated by the IMT should be catalogued and archived and a metadata summary developed for all data.

3.3.3 Data analysis

Results from analytical laboratories should be assessed by the OSMT for anomalies and for exceedance of the trigger values or initiation of SMP01 – Scientific monitoring of hydrocarbons in marine water and SMP-02 – Scientific monitoring of hydrocarbons in marine sediments.

Data and information from this OMP (including OSMT advice) will be provided to the IMT for review by the Incident Management Team Leader (IMTL) and the onsite PIC and be used to inform the decision making on response strategies.

4 Reporting

4.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly notify the OMT and seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

4.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO Pty Ltd should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other OMPs and SMPs
- Reports detailing the physical and chemical characteristics of spilled hydrocarbons, along with concentrations in water and sediments, as well as modelled hydrocarbon weathering, should be provided to the IMT. Reports should document whether:
  - the termination criteria for the OMP have been reached
  - SMP initiation criteria have been reached.

5 Pre-mobilisation activities

Consider the following prior to mobilising scientific resources to implement this OMP in the field.

5.1 Pre-planning

The information in Section 3 should be used to frame the monitoring strategy, sampling design, methods and locations, having regard to current/future weather conditions and other variables.

The preliminary planning will inform the initial selection and procurement of personnel, equipment and logistics support, which will streamline mobilisation and contribute to the safe and efficient execution of the fieldwork.

5.2 Personnel

In addition to the generic staff requirements described in the Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (OSMP) (4716-HS-H0114), staff required to implement OMP-01 should hold the following qualifications and competencies:

- Senior marine scientist – to assist in defining the monitoring program design
- Marine scientist(s) – to undertake OMP under the direction of senior marine scientist
- Vessel staff – to assist in the deployment and recovery of sampling equipment.

Note that, where practicable, personnel that have multiple competencies should fulfil more than one role to increase the efficiency of the OMP implementation.

All marine scientists deployed to the field work should be competent in and/or experienced in collecting hydrocarbon samples, water samples and water quality data.

Hydrocarbon surveillance may require vessels, aircraft or vehicles and therefore, additional team members and qualifications required (e.g. offshore medical) where practicable. However, given the environmental emergency situation in which OMP-02 would be implemented, incident controllers should use good judgement when deploying teams to the field.

5.3 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for OMP-02:

- Vehicles for accessing survey areas; may include vessels, aircraft or unmanned aerial vehicles (UAV) suitable for use as observation platforms, as required
- Video cameras, storage media and batteries (with spares)
- Digital still and video cameras (optionally with global positioning system (GPS)), storage media and batteries (with spares)
- GPS
- Chain of Custody (CoC) sheets
- Clean seawater for rinsing
- Cleaning agent (e.g. Decon 90)
- Coolers (including ice bricks) for sample transport
- Digital camera (including spare memory card and battery)
- Glass bowls and plastic spoons or homogenising sediments
- Handheld GPS
- Job Hazard Analysis (JHA)
- Laboratory address labels
- Large heavy duty plastic bags
- Material Safety Data Sheets (MSDS) for all chemicals
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Sample containers (including 10% contingency) with blanks sufficient to collect samples from at least five sites

- Sediment processing equipment (e.g. metal buckets, measuring cylinders)
- Sediment sampler (e.g. van Veen) including spares where practicable
- Submersible hydrocarbon fluorometer
- Suitable lifting equipment (e.g. davit, A frame etc.) rated for intended loads
- Vessel(s) suitable for deployment
- Water quality profiler (e.g. CTR profiler) including dissolved oxygen
- Water samplers (e.g. bomb sampler, Niskin bottle, submersible pump etc.).

5.3.1 Preparation

The following equipment preparation will be undertaken:

- Confirm equipment resources and availability (e.g. number/type of water quality samplers, sampling containers, coolers, ice bricks etc.) to implement the sampling design as per the monitoring program. Sufficient sample containers and consumables should be available initially to sample at least five sites, with additional containers procured as needed
- Confirm that vessel(s) suitable for deployment of sediment sampling equipment, including load ratings for deployment of sediment samplers
- Confirm work procedures are available and staff are familiar with the operation of any equipment
- Confirm all Global Positioning System (GPS) units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

5.4 Logistics

Upon notification that OMP-02 has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase:

- Assemble competent field team (refer to Section 5.1), including required personal protective equipment (PPE)
- Assemble field consumables and equipment (refer to Section 5.3)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2.1)
- Confirm survey sampling plan and continually update as new situational awareness information becomes available
- Co-ordinate National Association of Testing Authorities (NATA)-accredited laboratories to confirm availability, limits of detection, obtain sample analysis quotes and arrange provision of appropriate sample containers, CoC forms, coolers and ice bricks
- Confirm information on sampling holding times and requirements for collection and transport of sediment samples to analytical laboratories
- Develop and implement JHA and TEO Pty Ltd health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Arrange transportation for collected samples from field to laboratory

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

Appendix A.3 OMP-03 – Shoreline Assessment (4716 HS H0114 03)

OMP-03 - Shoreline Assessment

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-03

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This OMP-03 - Shoreline Assessment for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This OMP-03 - Shoreline Assessment shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This OMP-03 - Shoreline Assessment has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
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References

Document code	Title
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Oil Spill Monitoring Plan
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 – Scientific Monitoring of Hydrocarbons in Marine Water (Including Weathering)
4716-HS-H0114-12	SMP-02 – Scientific Monitoring of Hydrocarbons in Marine Sediments
4716-HS-H0114-13	SMP-03 – Scientific Monitoring of Shoreline and Intertidal Benthos
4716-HS-H0114-14	SMP-04 – Scientific Monitoring of Subtidal Benthos
4716-HS-H0114-15	SMP-05 – Scientific Monitoring of Seabirds and Shorebirds
4716-HS-H0114-16	SMP-06 – Scientific Monitoring of Sea Lions, Cetaceans and Turtles
4716-HS-H0114-17	SMP-07 – Scientific Monitoring of Fisheries Resources

Term definitions and abbreviations

Term or abbreviation	Definition
4WD	Four wheel drive
CHA	Cliff Head Alpha
GIS	Geographic Information Systems
GPS	Global Positioning System
HSEQ	Health, Safety, Environment, & Quality
IAP	Incident Action Plan
IMS	Invasive Marine Species
IMT	Incident Management Team
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and Scientific Monitoring Plan
PPE	Personal Protective Equipment
SMP	Scientific Monitoring Plan
TEO	Triangle Energy (Operations) Pty Ltd
UAV	Unmanned Aerial Vehicle

1 Rationale

The rationale and purpose for operational monitoring plan 03 (OMP-03) is to undertake an assessment of shorelines contacted by spilled hydrocarbons to assist in making decisions on appropriate management and resource allocation for shoreline responses (Shoreline protection and deflection and Shoreline clean-up).

The information collected during implementation of OMP-03 will:

- Inform the development of the Incident Action Plan (IAP), the Incident Management Team (IMT) and ongoing response operations to minimise environmental impacts of a shoreline response
- Inform the development of scientific monitoring programs (SMPs).

1.1 Objectives

The objectives of OMP-03 are to:

- Determine nature and extent of hydrocarbons on contacted shorelines
- Identify any considerations or constraints to shoreline response
- Identify the substrate, form, energy and biological character of shorelines.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of this OMP, the following inputs will be required:

- Release location
- Release time
- Hydrocarbon
- Estimated volume of spilled hydrocarbon
- Spill tracking / trajectory (OMP-01)
- Spill fate assessment (OMP-02).

2.2 Outputs to other plans

The information obtained during this OMP is used in the following other plans:

- Oil Spill Contingency Plan (OSCP) / Oil Pollution Emergency Plan (OPEP) – shoreline clean up response.

2.3 Relevant environmental data

Existing environmental data relevant to this OMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.4 Initiation criteria

The initiation criteria for implementation of OMP-03 comprise:

- Level 2 or Level 3 spill where hydrocarbon contact with shorelines is predicted or actual shoreline contact is observed.

2.5 Termination criteria

The termination criteria for this OMP comprise:

- Confirmation that source is controlled

AND

- The incident response has been terminated by the IMT

OR

- The information acquired by implementation of this OMP no longer informs decision making by the IMT

OR

- SMP03 has been implemented.

3 Methodology

3.1 Monitoring strategy

OMP-03 is intended to assess hydrocarbon contamination on shorelines in the event of a spill. This intention will be fulfilled by:

- Determining the areas of the shoreline that have been contacted by spilled hydrocarbons
- Determining the nature and extent of the hydrocarbon contact.

Such information will be of use to the IMT in determining the effectiveness of response strategies implemented to date. It will also inform decision making regarding implementation of the shoreline clean up response strategy.

Shoreline contact also triggers the implementation of SMP-03 – Scientific Monitoring of Shoreline and Intertidal Benthos (4716-HS-H0114-13). SMP-03 constitutes a longer term scientific assessment of the effects of hydrocarbon exposure on shoreline and intertidal biota.

3.1.1 Assessment platforms

Shoreline assessments can be undertaken from several survey platforms, each with advantages and limitations:

- Aerial platforms (e.g. fixed wing, helicopter, UAV)
  - Advantages:
    - Can cover large areas rapidly
  - Disadvantages:
    - Difficult for observers to collect detailed information on shoreline and hydrocarbon conditions
    - High cost
    - Safety considerations
    - Limited endurance
- Vessels
  - Advantages:
    - Can access coastline not accessible by vehicles (e.g. offshore islands, remote coastline)
    - Good endurance
  - Disadvantages:
    - Difficult for observers to collect detailed information on shoreline and hydrocarbon conditions
- Shoreline surveys (e.g. on foot, four wheel drive (4WD) vehicles)
  - Advantages:
    - Provides for very thorough assessment yielding detailed information
    - Good endurance
    - Simplified logistics and safety considerations
    - Low cost
  - Disadvantages:
    - May result in impacts to coastline (e.g. beach damage from vehicle use)
    - Difficult to access remote areas (may require vessels or helicopters for transportation).

3.1.2 Shoreline types

The hydrocarbon spill risk assessments carried out in relation to the Cliff Head development have identified several shoreline types on the mainland and offshore island coastlines that may be affected by the credible worst case hydrocarbon spill scenarios:

- Sandy beaches: the most commonly occurring shoreline type on the mainland coast that may be affected by a hydrocarbon spill. Sandy beaches are generally subjected to high wave energy and are accessible by 4WD vehicles, with numerous access points along the coastline. Sandy beaches are less common on offshore islands.
- Intertidal platforms: limestone intertidal platforms occur between sandy beaches and along the coastlines of offshore islands. Intertidal platforms constitute a relatively small portion of the coastline that may be affected by a hydrocarbon spill.
- Port of Dongara: the port facilities at Dongara may be affected in the event of a hydrocarbon spill. The facilities consist of a small port with boat pens and moorings surrounded by a limestone riprap sea wall. There is a single narrow entrance into the port.
- Port of Geraldton: the port of Geraldton is the major port facility on the Midwest coastline and serves as export facility for a range of commodities such as ore and minerals, livestock and grain from the commercial harbour. The port also hosts a fishing boat harbour with boat pens hosting commercial fishing and recreational boats. The port is surrounded by riprap sea walls.

3.2 Sampling design

3.2.1 Identification of hydrocarbon affected shorelines

Identification of shorelines affected by hydrocarbons will be determined by OMP-01 – Oil Distribution Monitoring (4716-HS-H0114-01. The IMT should use the information provided

Note that any other reports of shoreline contact (either by hydrocarbon spill response teams or other parties) should be logged by the IMT and considered when determining affected shorelines.

3.2.2 Determine sectors and segments

Assessment of shoreline response will initially divide the affected shoreline into sectors, with a series of segments within each sector. Sectors are typically determined based on logistical considerations, such as access nodes (e.g. boat ramps, beach tracks), waste management facilities and equipment stored. Given the nature of the coastline surrounding the Cliff Head development, coastal settlements are expected to be a suitable basis for the determination of sectors.

Within sectors, a series of segments will be determined. Segments consist of lengths of shorelines that are discrete pieces of coastline. Segments can be based on a contiguous shoreline type (e.g. sandy beaches, intertidal platforms). Given the length of sandy beaches along the mainland coastline in the vicinity of the Cliff Head project, it may be useful to divide larger segments into sub-segments, depending on the nature and scale of shoreline contamination. Note that sectors may be refined based on feedback from teams during the assessment of shorelines (Section 3.2.3)

Refer to Appendix A.1 for instructions on determining sectors and segments during implementation of OMP-03. Aerial photos may be a good resource to assist in delineating sectors and segments. Shoreline sectors and segments should be clearly marked on maps or within a geographic information system (GIS) by the IMT.

3.2.3 Assessment of shorelines

Once sectors and segments have been determined, a rapid assessment of the level of shoreline contact should be undertaken. It is strongly recommended that this be carried out by observers on an aerial platform, in conjunction with OMP-01 – Oil Distribution Monitoring (4716-HS-H0114-01). Instructions for undertaking a rapid aerial assessment of shorelines are provided in Appendix A.2. If aerial survey platforms are unavailable, rapid shoreline assessments may be undertaken from vessels or by teams on foot, although such assessments will take longer to complete a given section of coastline.

Once a rapid assessment of the shoreline segments has been undertaken, a more detailed assessment of shoreline contact should be undertaken by observers on the ground. This assessment should examine the level of oiling on the sand surface and sub-surface (if present). The shoreline assessment process should be carried out in accordance with the procedures described in Appendix A.5 and Appendix A.6, and recorded on the TEO Shoreline Oiling Assessment Form (Appendix B).

The nature of the hydrocarbon and the shoreline determine the effects of hydrocarbon contact on the shoreline. Information of the nature of the spilled hydrocarbons will be provided by OMP-02 – Oil Character and Fate Modelling (4716-HS-H0114-02). The nature of the shoreline can be determined during the shoreline assessment. Refer to Appendix A.2 or details on determining the nature of the shoreline substrate.

All shoreline assessments should be supported by photographic evidence that is spatially referenced (e.g. GPS integrated cameras/images, coordinates or images recorded as waypoints).

Hydrocarbons stranded shorelines typically accumulates at the top of the swash zone (i.e. the upper limit of the waves on the shore). However, buried hydrocarbons may be present along the shoreline profile, so monitoring for buried hydrocarbons should occur from the low tide mark to the top of the swash zone.

Note that during the shoreline assessment, samples of hydrocarbons can be collected. Refer to OMP-01 – Oil Distribution Monitoring (4716-HS-H0114-01) for information on the collection of shoreline hydrocarbon samples.

The data collected by teams undertaking shoreline assessment (including photographs) should be provided to the IMT as quickly as practicable. Where completed copies of the shoreline oiling assessment form cannot be immediately provided to the IMT, the results of the shoreline assessment should be communicated verbally (including the coordinates of the area assessed) to the IMT to inform decision making. Rapid communication to the IMT will facilitate the implementation of effective response strategies in a timely manner.

Shoreline clean-up is a response strategy that may be implemented by TEO on the event of a hydrocarbon spill. This response has the potential to alter the profile and morphology of a shoreline, particularly sandy beaches which occur along much of the mainland coast in the vicinity of the Cliff Head project. In the event of implementation of shoreline clean-up within sectors identified by OMP-03, monitoring of the shoreline profile should be undertaken. Shoreline profile monitoring can be undertaken through the use of several survey techniques; however, the beach should be surveyed prior to the commencement of shoreline clean-up operations. Refer to Appendix A.3 for procedures to undertake beach profiling.

3.3 Data management

3.3.1 Field data management

Field data will be recorded on shoreline oiling assessment forms (Appendix B) during monitoring and communicated to IMT via communications channels (telephone, email, radio, email). The IMT will document all relevant information at the incident control centre as per the incident communications arrangements described in the OSCP / OPEP.

Digital field data (e.g. photographs) should be downloaded as soon as practicable following retrieval of the instrument and backed up onto independent storage (e.g. portable hard drives). Photographs should be named and stored using a system that clearly links images to sites and facilitates storage, retrieval and back up. Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

3.3.2 Office data management

All communications with the field team and the IMT will be recorded. All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

3.3.3 Data Analysis

Data provided to the IMT will be assessed and used to inform spill response operations. This information will also be used to inform the design of SMPs.

4 Reporting

4.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly notify the IMT and seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

4.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other OMPs and SMPs
- Reports detailing the nature and extent of shoreline contact within sectors should be routinely provided to the IMT following completion of an assessment
- The IMT should record whether the shoreline assessment termination criteria have been met, as well as whether any relevant SMP initiation criteria have been met.

5 Pre-mobilisation activities

The following should be considered prior to mobilising equipment and personnel resources to implement this OMP in the field.

5.1 Personnel

In addition to the generic staff requirements described in the overarching operational and scientific monitoring plan (OSMP) (4716-HS-H0114), staff required to implement OMP-03 should hold the following qualifications and competencies:

- Shoreline assessors – competent to complete a shoreline assessment of hydrocarbon impacts.

Note that, where practicable, personnel that have multiple competencies should fulfil more than one role to increase the efficiency of the OMP implementation.

Shoreline assessment may require vessels, aircraft or vehicles to access the area to be assessed. Additional team members and qualifications may be required (e.g. offshore medical, 4WD experience).

5.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for OMP-03:

- Vehicles for accessing survey areas; may include vessels, aircraft or unmanned aerial vehicles (UAV) suitable for use as observation platforms, as required
- Video cameras, storage media and batteries (with spares)
- Digital still and video cameras (optionally with global positioning system (GPS)), storage media and batteries (with spares)
- GPS
- Shovels / trowels
- TEO shoreline oiling assessment forms
- Measuring tapes

- Marker stakes
- Theodolite and staff
- Guidance material on the identification and assessment of hydrocarbons on shorelines, including the Oil Spill Monitoring Handbook (CSIRO, 2016).

5.2.1 Preparation

The following activities will need to be undertaken, to confirm equipment is in working order, prior to mobilisation to the field:

- Develop sampling program consistent with principles in OSMP, this OMP and available existing data
- Confirm equipment resources and availability
- Confirm all GPS units and digital cameras are in good working order and that sufficient spare batteries and memory cards have been obtained
- Check field laptops, confirming that laptop batteries, power cable, licenses, logins are available and are functional
- Check video cameras, confirming that they have sufficient batteries; storage media, power cables, and each are functional
- Arrange transport of equipment to mobilisation point.

5.3 Logistics

Upon notification that OMP-03 has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase:

- Assemble competent field team (refer to Section 5.1), including required personal protective equipment (PPE)
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel, aircraft or vehicle(s) for monitoring operations
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2.1)
- Confirm survey sampling plan and continually update as new situational awareness information becomes available
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure field consumables and equipment (refer to Section 5.2).

6 References

CSIRO (2016). Oil Spill Monitoring Handbook (CSIRO, 2016).

Appendix A. Oil Spill Monitoring Handbook

Appendix A.1 Guideline for determining sectors and segments

GUIDELINE FOR DETERMINING SECTORS AND SEGMENTS	S.1

Rationale
Shorelines should be divided into individual "work sites" and "monitoring sites" so that data can be recorded systematically.

Methodology				
1	Identify length of shoreline impacted or that could be impacted by oil.			
2	Consult topographic map and:			
	2.1	Identify access to shoreline.		
	2.2	Estimate travel time between consecutive shorelines.		
	2.3	Note available support areas (open spaces, car parks).		
3	Divide shorelines into Sectors using the following guidelines.			
	Sectors are based on logistics; i.e. there may be little easy access between the Sectors but there must be easy and common access within Sectors. For large scale responses, this could mean that each Sector may have a separate equipment store, field command centre, canteen, etc.			
	3.1	Travel time between any two parts of the shoreline should be less than two hours.		
	3.2	Travel time between nominated Operations/Support Centres and all shorelines within the Sector should be less than 1 hour.		
4	Name (number) Sectors and mark on maps or GIS (record GPS coordinates of boundaries).			
5	Divide each Sector into Segments. Segments should be delineated using the following guidelines:			
	Segments are generally "work sites" and boundaries are based on substrate, shoreline type and length.			
	5.1	Segments should be comprised of the same substrates type or combination of substrates (refer to Guideline S.2). Substrate type in the oiled zone (usually the upper intertidal zone) is of primary importance.		
	5.2	Other features affecting the choice of cleanup should be constant within each Segment e.g:		
		• Drainage	• Exposure (wave energy)	• Biological character
		• Gradient	• Access point(s)	
	5.3	In some Segments, tidal zones are made up of quite different substrates and may need different cleanup methods. These can be subdivided into Subsegments based on tidal elevation.		
6	Name (number) Segments and mark on maps or GIS (record GPS coordinates of boundaries).			

Appendix A.2 Guideline for characterising shoreline substrate

GUIDELINE FOR CHARACTERISING SHORELINE SUBSTRATE	S.2

Rationale

Substrate type (particle size) determines the size of the spaces between particles and this in turn influences the depth to which oil will penetrate, and the ease with which wave action will remove the oil. These considerations are important in determining the need for, and type of, shoreline cleanup.

Methodology

Type	Abbr.	Descriptive Terms	Explanation
Bedrock or Rock	R	• Porous/non-porous • Broken/not broken (crevices/no crevices).	Porosity and crevices increase the likely persistence of the oil.
Boulder	B	• As above.	>256mm diameter: Larger than a head.
Cobble	C	• Porous (e.g. coral, pumice)/non-porous.	64 – 256mm: Fist or brick to head-sized
Pebble	P	• Or use "shingle" if flattened.	4 – 64mm: Pen diameter to fist sized.
Granules/ Gravel	G	• Rounded/flat. • Compacted/loose.	2 – 4mm diameter.
Sand	S	• Fine to coarse.	0.06 – 2mm diameter.
Mud/Silt/ Clay	M	• Note organic matter (debris/ fauna/ flora). • Consolidated/loose. • Dry (e.g. mud cliffs).	<0.06mm diameter. Field Test: Mix with water: If it "clouds up" it is silt/mud. If it sinks/clears it is sand.
Earth/ Soil	E	• Generally only applicable to cliffs and seawalls.	
Ice	I	• Likely only in the Antarctic territories.	
Shellgrit	Sh	• Wet/dry.	Usually with sand (Sh/S).
Coral(1)	Co	• Rubble/Boulder/ Cobble (e.g. Co-C).	Use to describe dead coral areas, e.g. coral cobble.
Concrete(2)	Cc	• Rubble; rip-rap.(2)	Artificial substrates/forms should be described and marked on segment maps.
Wood	W	• Debris/logs; pilings.	Debris can overlay other substrates.
Metal	Mt	• Pilings, sheeting.	Usually artificial structures.

1. *If corals are live, the shoreline should be described as coral noting its biological character and substrate type.*
2. *The abbreviation "A" can be used to designate artificial structures when they are not otherwise easily described, e.g. A-B would describe artificial boulder shoreline (i.e. rip-rap).*

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Appendix A.3 Guideline for determining beach profile

GUIDELINE FOR DETERMINING BEACH PROFILE (GRADIENT)	S.3

Rationale

Physical cleanup methods can alter the elevation or profile of sand, pebble or cobble beaches. This may lead to erosion of beach or back beach areas. Shoreline profile may need to be monitored during cleanup, particularly if heavy machinery is used.

Methodology

S.3A Use of Marker Stakes

This is the simplest method and is suitable for low energy shores where manual rather than mechanical cleanup is used. It detects changes in sediment distribution but does not allow an accurate profile of the beach to be determined.

1	Hammer wooden or steel stakes into the beach at a number of locations and at various tidal elevations.
2	Measure the distance between the top of each stake and the sediment surface (H in Figure S.3.1).

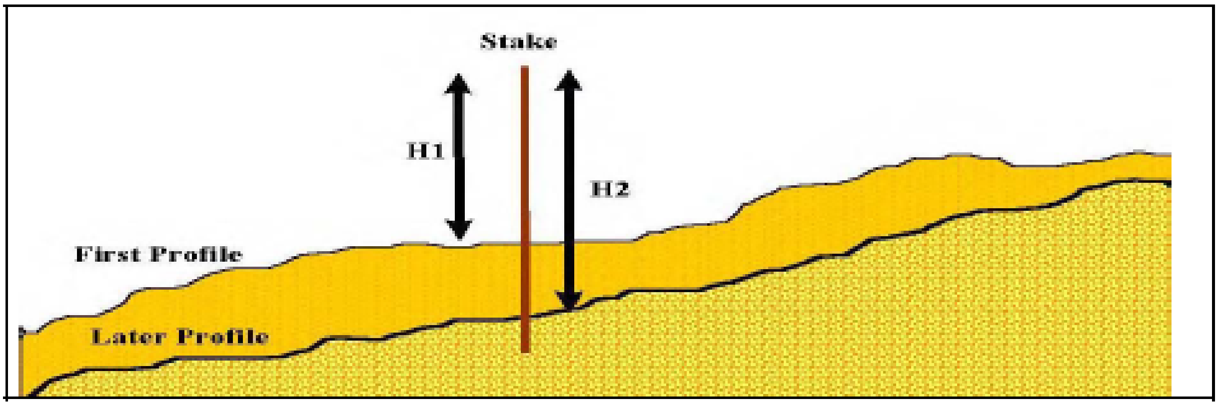


Figure S.3.1

S.3B Pole and Horizon Method 1

This method is suitable for all "soft" sediment shoreline types, i.e. those that allow a stake to be pushed or hammered into the surface.

1	Fix stakes (the "back stakes") along the beach above the high tide mark (i.e. in the Supratidal Zone).
2	A linear transect is established across the beach (from supratidal zone to lower intertidal zone). The orientation of this is identified using a compass bearing from each "back stake" position.
3	To measure beach profile, a second stake (the "front" stake) is placed 2-4 m along the transect, and a tape or pole is used to align the top of the back stake to the horizon, and the eye of an observer on the back stake. Alternatively a spirit level can be used to ensure that the pole is horizontal.
4	The back stake is used to measure changes in sediment height; i.e. changes in the distance between the tape level and the top of the stake (H in Figure S.3.2).
5	This procedure can be repeated at regular intervals along the transect.

	Page 1 of 3	S.3

S.3B Pole and Horizon Method 1 Continued

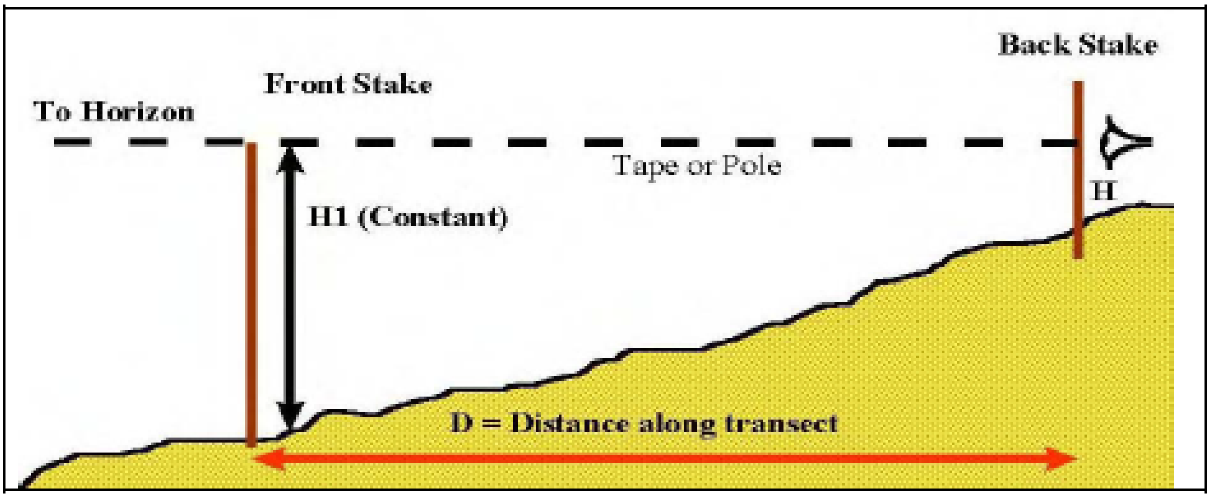


Figure S.3.2

S.3C Pole and Horizon Method 2

This is similar to Method 2.3B except that it does not require the front stake to be pushed into the surface.

1	Fix stakes (the “back stakes”) along the beach above the high tide mark.
2	A linear transect is established across the beach (from supratidal zone to lower intertidal zone). The orientation of this is identified using a compass bearing from each “back stake” position.
3	To measure beach profile, a second stake (the “front” stake) is placed 2-4 m along the transect, and a tape or pole is used to align the top of the back stake to the horizon, and the eye of an observer on the back stake. Alternatively a spirit level can be used to ensure that the pole is horizontal.
4	The height between the sediment and the tape/pole at the front stake is measured (H1). The drop from the back stake to the front stake is H1-H0 (H0 is the height of the back stake, see Figure S.3.3)
5	This procedure is repeated at various intervals along the transect. Note if the “front stake” is left in place, measurements down-beach can be referenced from this point. This is an advantage if a pole (2-4 metres) is used to align stakes.

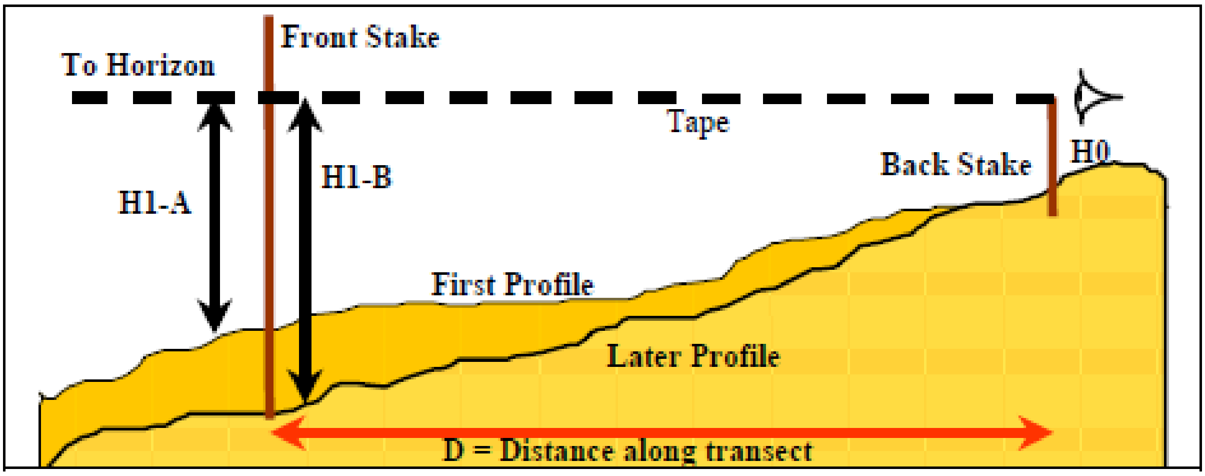


Figure S.3.3

S.3D Survey Using a "Theodolite"	
This is the most accurate method but requires specialised equipment.	
1	Fix stakes (the "back stakes") along the beach above the high tide mark (i.e. in the Supratidal Zone).
2	The theodolite can be used to measure the orientation of the transect, the height above the sediment of a forward measuring pole, and the height above the sediment surface of the theodolite.
3	When coupled with measured distances between the theodolite and the forward pole, the beach profile can be drawn.

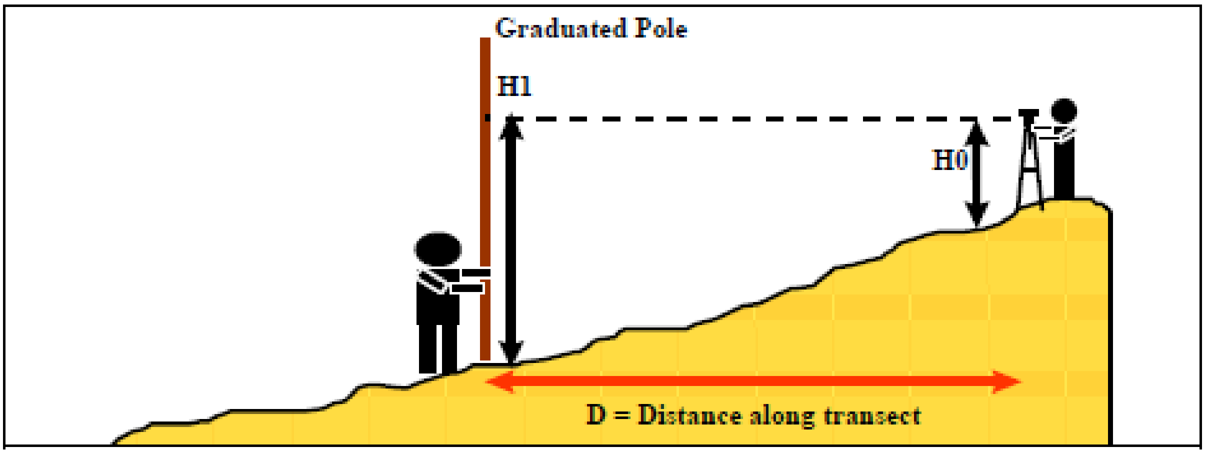


Figure S.3.4

Appendix A.4 Guideline for aerial survey of shorelines

GUIDELINE FOR AERIAL SURVEY OF SHORELINES	S.4

Rationale

A rapid means of estimating the location, length and extent of oiled shorelines. An accurate indication of oil thickness cannot be obtained using this technique. Ground surveys are usually still required. Note: A two person team is preferable for shoreline video/photo surveys.

Methodology

1	Select and commission aircraft. Aircraft should have:	
	1.1	Downward visibility (helicopter/fixed wing aircraft with over-fuselage wing).
	1.2	Global (Geographic) Positioning System (GPS).
	1.3	Slow speed, and
	1.4	Be suitable for low altitude (preferably a helicopter)
2	Assemble equipment required:	
	2.1	Map or chart, suitable for marking up (preferably laminated).
	2.2	Pens, pencils and eraser.
	2.3	Camera(s) (digital/video camera preferred, with date recording capability). Note: Check batteries and film.
	2.4	Map of coastline (topographic map rather than marine chart). Preferred scale is 1:10,000 to 1:30,000.
	2.5	Reliable watch (the aircraft will have a clock).
	2.6	Sunglasses.
3	Obtain information on the predicted shoreline impact area.	
4	Time flight (if possible) to correspond with low tide.	
5	Discuss flight and surveillance programme with the Pilot.	
6	Report departure time flight path and ETA to air control.	
7	Undertake a higher altitude (up to 500m) rapid fly over of the shoreline to gain an overall perspective of the extent of oiling. Use this to determine:	
	7.1	Length of shoreline to be surveyed during the current flight.
	7.2	Frequency timing of photographs (i.e. time of video or amount of film/ digital camera memory available).
8	Conduct a low altitude survey of target shoreline. Use the following guidelines for speed and altitude (the pilot will determine the limits to these):	

Altitude (m)	30	60	100	>100
Speed (Knots)	20	30	50	Not Recommended
	Helicopter recommended			

Note: A new video tape or roll of film should be used for each new survey. Digital camera memory should be cleared and backed up after each survey.

9	Record data:	
	9.1	Take video or still pictures at a downward angle of 30°-45°. Note: Unlike aerial surveillance over water it is not always possible to avoid photographing into the sun. A polarising filter may be used to reduce glare, but use of this filter should be recorded on the photograph log.

<table>
<tr><td rowspan="9">9</td><td rowspan="5">9.2</td><td colspan="2">Mark oil distribution on map. Estimate and mark on:</td></tr>
<tr><td>9.2.1</td><td>Tidal position of oil (upper, middle or lower intertidal).</td></tr>
<tr><td>9.2.2</td><td>Band width (see Guideline S.5).</td></tr>
<tr><td>9.2.3</td><td>Percentage cover (see Guideline M.3).</td></tr>
<tr><td>9.2.4</td><td>Shoreline substrate.</td></tr>
<tr><td>9.3</td><td colspan="2">Photo locations and direction should be marked on the coastal map using an arrow (direction) and number (sequence).</td></tr>
<tr><td>9.4</td><td colspan="2">A voice-over should be used to record the details shown in 9.2.1 to 9.2.4. The voice-over should also record place names and/or GPS references to aid in later verification of positions. Note: a direct GPS-camera link may be possible with some digital cameras.</td></tr>
<tr><td rowspan="3">9.5</td><td colspan="2">Completed video tapes and film should be labelled with:</td></tr>
<tr><td>9.5.1</td><td>Date and time</td></tr>
<tr><td></td><td></td><td>9.5.2</td><td>Location (GPS or geographic name) at which it was started and finished.</td></tr>
<tr><td>11</td><td colspan="3">Note: Separate surveys should overlap shoreline lengths by a few hundred metres or should include an obvious feature (building, headland, rock outcrop etc.) at the start of the following survey.</td></tr>
<tr><td rowspan="4">12</td><td colspan="3">At the end of each survey:</td></tr>
<tr><td>12.1</td><td colspan="2">Review and copy videos, digital photos or have film developed (at least two print sets).</td></tr>
<tr><td>12.2</td><td colspan="2">Edit video tapes/digital video if necessary.</td></tr>
<tr><td>12.3</td><td colspan="2">Label and catalogue videos/slides/photos.</td></tr>
</table>

	Page 2 of 2	**S.4**

Appendix A.5 Guideline for assessment of oiled shorelines: surface oil

GUIDELINE FOR ASSESSMENT OF OILED SHORELINES: SURFACE OIL — S.5

Rationale

Monitoring the extent and distribution of oil on shorelines is needed for planning shoreline response strategies, methods and cleanup. This procedure sets out the method for describing oil on shoreline Segments (Guideline S.1). The general distribution of oil over large lengths of shoreline is monitored by using modified aerial surveillance procedures (Guideline S.3).

Methodology

1	Divide shoreline into Sectors and Segments (see Guideline S.1)		
2	Record the following shoreline descriptors:		
	2.1	Length	In metres
	2.2	Width	In metres, from high tide to low tide.
	2.3	Gradient	In degrees; approximate or as per Guideline S.3
	2.4	Energy	High, medium or low as suggested by form
	2.5	Substrate	Mud, sand, pebble etc. as per Guideline S.2
	2.6	Form (or type)	Cliff, platform cobble beach etc.
3	For each Segment, draw a sketch map showing the approximate location of the oil.		
4	Record the following parameters for the oily band:		
	4.1	Length	In km for Sectors or total, in m, for Segments. The distance the oily band extends along the shoreline.
	4.2	Width	In metres. Average width of the oily band within a Segment or Sector. Measured across a beach from high to low elevations.
	4.3	% Cover	Visual estimate of the percentage of the band (or average of bands). As per Figure below;

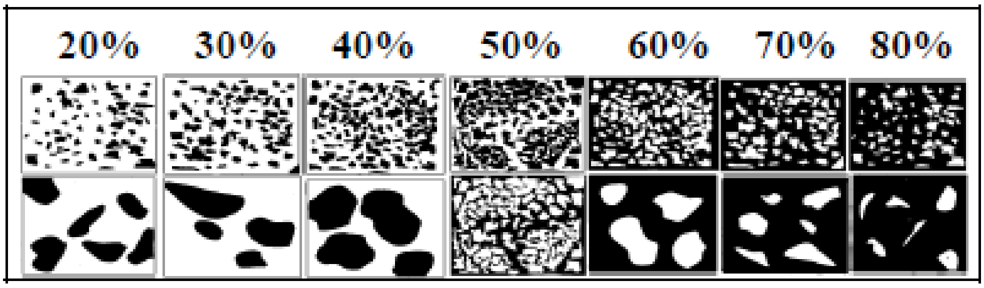


Figure S.5.1

	4.4	Oil Thickness	Po	Pooled oil. Can be estimated or measured in mm or cm.
			Cv	Cover. In mm, this is measurable (> 1mm thick)
			Ct	Coat. Can be scratched off rock with fingernail. Ct will mask the colour and texture of underlying substrate.
			St	Stain. Cannot be scratched off rock. Texture of substrate is visible through the oil
			Fi/ Sh	Film (Fi) or Sheen (Sh). Transparent. The colour and texture of substrate is visible through the oil
5	If necessary, or requested, classify surface oiling as per Tables overpage.			

S.5 Methodology Continued

Surface Oil Coverage

	Width of Oiled Band			
% Oil Cover	>6m	3-6m	0.5-3m	<0.5m
51-100	High	High	Medium	Low
11-50	Medium	Medium	Low	Very Low
1-10	Low	Low	Very Low	Very Low
<1	Very Low	Very Low	Very Low	Very Low

Surface Oil Classification

	Surface Oil Coverage			
Ave. Thickness	High	Medium	Low	Very Low
Pooled/Thick	Heavy	Heavy	Light	Light
Cover (>1mm)	Heavy	Heavy	Moderate	Light
Coat	Moderate	Moderate	Light	Very Light
Stain/Film	Light	Light	Very Light	Very Light

Figure S.5.2

(Source Wardrop 2000 as adapted from Owens & Sergy, 1994)

Note: Use Band Width (W) and % Coverage (%) to determine the surface oil cover, and then use oil Thickness (T) to classify the degree of oiling; the Surface Oil Classification.

Appendix A.6 Guideline for assessment of oiled shorelines: sub-surface oil

GUIDELINE FOR ASSESSMENT OF OILED SHORELINES: SUB-SURFACE OIL	S.6

Rationale

Monitoring the extent and depth of oil in shorelines is needed for planning shoreline response strategies, methods and cleanup. This procedure sets out the method for describing subsurface oil.

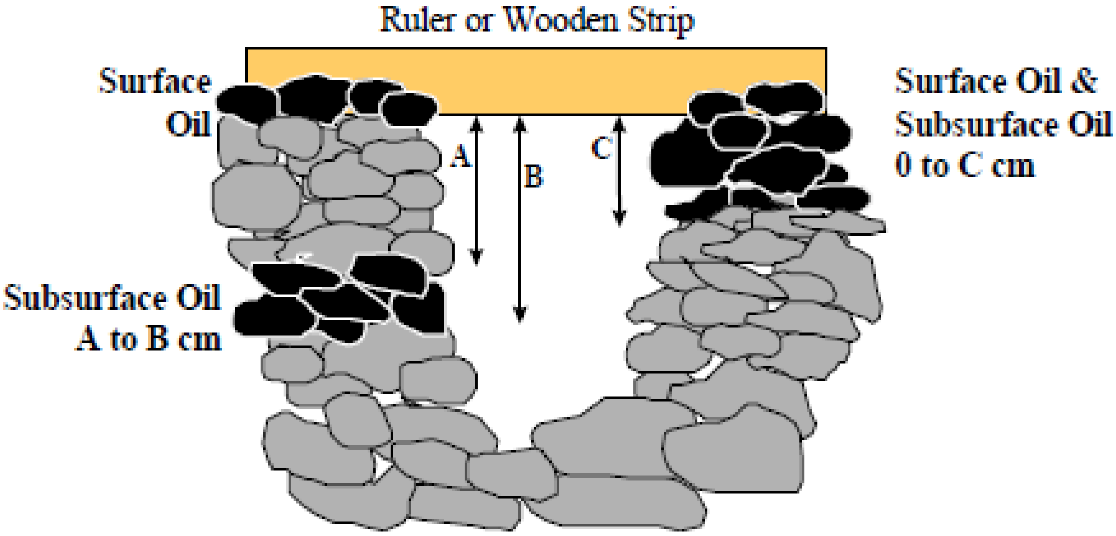
Methodology

1	Divide shoreline into Sectors and Segments (see Guideline S.1).		
2	Record the following shoreline descriptors:		
	2.1	Length	In metres.
	2.2	Width	In metres, from high tide to low tide.
	2.3	Gradient	In degrees; approximate or as per Guideline S.3.
	2.4	Energy	High, medium or low as suggested by form.
	2.5	Substrate	Mud, sand, pebble etc. as per Guideline S.2.
	2.6	Form (or type)	Cliff, platform cobble beach etc.
3	Dig trenches or pits to detect subsurface oil. Narrow trenches are more suitable for sandy substrates. Pits are more suitable for cobbles or small boulder substrates. The depth required will depend on substrate type and, for sand – pebbles, on sediment mobility (wave energy).		
4	For each Segment, draw a sketch map showing the approximate location of subsurface oil detected.		
5	If possible, record the following parameters for the oily band:		
	5.1	Length	In km for Sectors or total, in metres, for Segments. The distance the oily band extends along the shoreline.
	5.2	Width	In metres. Average width of the oily band within a Segment or Sector. Measured across a beach from high to low elevations.
	Note percentage cover is difficult to estimate for subsurface oil. It can be approximated by digging a large number of pits through identified subsurface bands but this is usually not feasible.		
6	For each pit, or location along a transect trench, record the following:		
	6.1	Minimum depth of oil	In metres or cm. The distance from the beach surface to the top of the buried layer (see Figure S.6.1).
	6.2	Maximum depth of oil	In metres or cm. The distance from the beach surface to the bottom of the oil layer.
	6.3	Substrate type	At various depths, or in the oily bands as required.
7	Describe the oil in the oily layer:		
	7.1	Fluid Oil	Low viscosity, i.e. will flow relatively freely.
	7.2	Viscous Oil	Oil will flow slowly.
	7.3	Mousse/ Emulsified oil	Generally viscous but distinguishable from the above by colour change (i.e. becomes lighter).
	7.4	Tar	Very viscous, and sticky oil. Tar tends to hold its shape when disturbed. Flows very slowly or not at all.

	Page 1 of 2	S.6

S.6 Methodology Continued

For large substrates (cobble – boulder)



For small substrates (silt/mud – pebble)

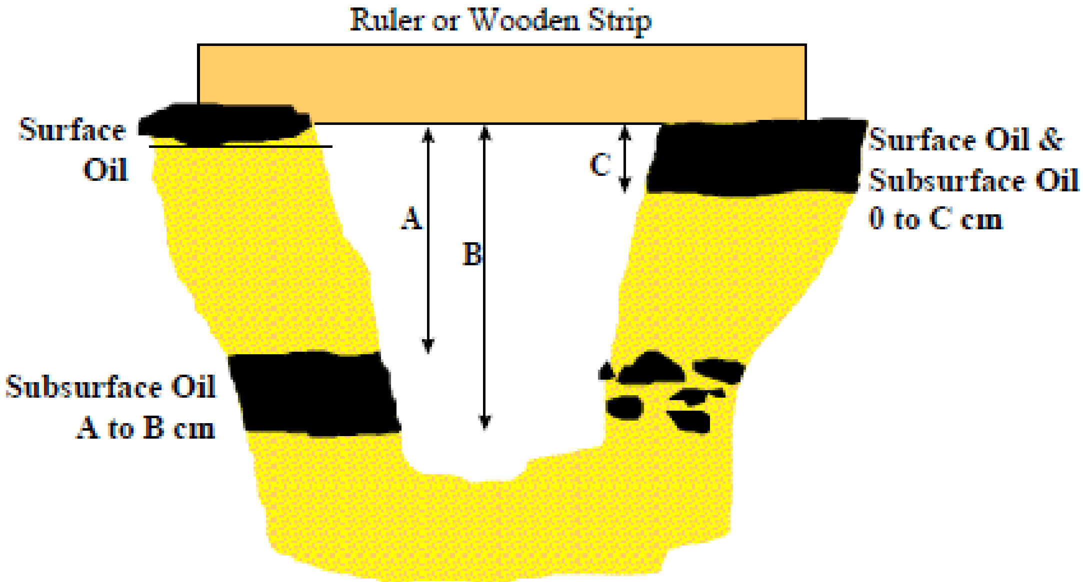


Figure S.6.1
(Source Wardrop 2000 as adapted from Owens & Sergy, 1994)

Appendix B. Shoreline Oiling Assessment Form

SHORELINE OILING ASSESSMENT FORM			
This Report should be submitted to the Site Emergency Controller (SEC) who will forward it to the IMTL.			
Incident		**Ref. No.**	
Date	**_____ /_____ / _____**	**Time**	**______ : _____ (24 hr)**

SEGMENT NO:		**REPORTING DETAILS:**
Topo'/Other Map (No.):		Assessment By Name: ___________________
Map Reference:		Position: __________________
Name of Beach or Location Description:		Date: _____/____/_____ Time: ____AM/PM
		Report To Name: ____________________
Access Via:_________________________		Position: __________________
❑Foot only ❑Road ❑4WD ❑Boat ❑Heli		Date Rec'd: ___/___/__ Time: _____AM/PM
Hazards?		First Assessment for Segment? ❑ Yes ❑ No

OIL DISTRIBUTION AND CHARACTER												
PARAMETER	LITZ*			MITZ*			UITZ*			SUPRATIDAL		
Shoreline Type												
Substrate Type												
Width of Shoreline												
Oil Band Width (m)												
Cover in Oil Band (%)												
Length of Coast Oiled												
Surface Oil Thickness												
Appearance												
Debris Present												
Oiled Debris												
Depth of Oiling (From Surface)												
Buried Oil Bands (Min.-Max. in m/cm)												
Description of Buried Oil												

** LITZ=Lower Intertidal Zone, MITZ=Mid Intertidal Zone, UITZ=Upper Intertidal Zone.*

SEE OVERPAGE FOR PAGE 2 OF SHORELINE OILING ASSESSMENT FORM

PAGE 2 OF SHORELINE OILING ASSESSMENT FORM

SKETCH/MAP

Scale:

NOTES

Appendix A.4 OMP-04 – Wildlife Impact Monitoring (4716 HS H0114-04)

OMP-04 - Wildlife Impact Monitoring

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-04

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This OMP-04 - Wildlife Impact Monitoring for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

Bryce Donaldson
Manager HSE & Regulatory
Triangle Energy (Operations) Pty Ltd

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West Perth WA 6005
PO Box 51
West Perth WA 6872
bdonaldson@triangleenergy.com.au

This OMP-04 - Wildlife Impact Monitoring shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This OMP-04 - Wildlife Impact Monitoring has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

Distribution List

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3	Anthony See, Asset & Integrity Manager (TEO)
4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Oil Spill Monitoring Plan
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 – Scientific Monitoring of Hydrocarbons in Marine Water (Including Weathering)
4716-HS-H0114-12	SMP-02 – Scientific Monitoring of Hydrocarbons in Marine Sediments
4716-HS-H0114-13	SMP-03 – Scientific Monitoring of Shoreline and Intertidal Benthos
4716-HS-H0114-14	SMP-04 – Scientific Monitoring of Subtidal Benthos
4716-HS-H0114-15	SMP-05 – Scientific Monitoring of Seabirds and Shorebirds
4716-HS-H0114-16	SMP-06 – Scientific Monitoring of Sea Lions, Cetaceans and Turtles
4716-HS-H0114-17	SMP-07 – Scientific Monitoring of Fisheries Resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
CHA	Cliff Head Alpha
CoC	Chain of Custody
CRS	Coordinate Reference System
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DOX	Dongara Airport Code
EMBA	Environment that may be affected
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations 2000
GDA2020	Geodetic Datum of Australia 2020
GPS	Global Positioning System
HSEQ	Health, Safety, Environment, & Quality
IATA	International Air Transport Association
ICAO	Dongara Airport Code
IMT	Incident Management Team
JHA	Job Hazard Analysis
MGA	Map Grid of Australia
MNES	Matters of National Environmental Significance
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and Scientific Monitoring Program
PPE	Personal Protective Equipment
SMP	Scientific Monitoring Plan
TEO	Triangle Energy (Operations) Pty Ltd
UAV	Unmanned Aerial Vehicle
YDRA	Dongara Airport Code

1 Rationale

The purpose and aim of Operational Monitoring Plan 04 (OMP-04) is to provide an assessment of the impacts of spilled hydrocarbons and spill response activities on wildlife during spill response activities. Data collected during implementation of this OMP will provide information on:

- The types of wildlife that have been, or are at risk of, exposure to spilled oil and response activities
- The nature of impacts to wildlife from spilled oil and response activities
- Estimates of the numbers and locations of wildlife that been, or are at risk of, exposure to spilled oil and response activities
- The locations of wildlife, in particular aggregations, that have been or are at risk of exposure to spilled oil.

A range of marine fauna have been identified as occurring within the environment that may be affected from a hydrocarbon spill in relation to the Cliff Head development, including species protected under State (e.g. *Biodiversity Conservation Act 2016*) and Commonwealth (e.g. *Environment Protection and Biodiversity Conservation Act 1999*), including matters of national environmental significance (MNES). Taxa potentially occurring within the environment that may be affected (EMBA) of a hydrocarbon spill include:

- Cetaceans
- Pinnipeds
- Reptiles
- Seabirds and migratory shorebirds
- Sharks and rays
- Fishes
- Invertebrates.

Refer to the hydrocarbon spill risk assessments in the environment plans in relation to the Cliff Head project for additional information on marine fauna that may be affected by a hydrocarbon spill.

The information collected during implementation of OMP-04 will be used to inform ongoing response operations, as well as the development of scientific monitoring programs (SMPs). Implementation of OMP-04 is a component of the 'Wildlife Response' spill response strategy in the Cliff Head Alpha (CHA) Operations Oil Spill Contingency Plan (OSCP) (10HSEQENVPL02) or Cliff Head Alpha Operations Oil Pollution Emergency Plan (OPEP) (10HSEQENVPL15).

1.1 Objectives

The objectives of OMP-04 are to:

- Identify and quantify wildlife that have been, or are at risk of being, exposed to spilled oil
- Determine the location(s) of wildlife that have been, or are at risk of being, exposed to spilled oil
- Inform the initiation and implementation of response strategies, particularly 'Wildlife Response', during spill response operations
- Inform the initiation of scientific monitoring plans (SMPs).

2 Decision-making Inputs and Outputs

2.1 Inputs from other plans

In order to inform the initiation and design of this OMP, the following inputs will be required from the Oil Spill Contingency Plan (OSCP) / Oil Pollution Emergency Plan (OPEP) and other OMPs:

- Release location
- Release time
- Hydrocarbon type (either vessel fuel or Cliff Head crude)
- Estimated volume of spilled hydrocarbon Current and previous distribution of hydrocarbons from the spill (OMP-01)
- The predicted spill trajectory (OMP-02)
- Known or suspected fauna distributions based on available data (e.g. Oil Spill Response Atlas, Environment Plans, Overarching OSMP)
- Any observations of marine fauna exposed or at risk made during spill response activities.

2.2 Outputs to other plans

The information obtained during this OMP will be used in the following SMPs:

- Scientific monitoring of seabirds and shorebirds (SMP-05)
- Scientific monitoring of sea lions, cetaceans and turtles (SMP-06)
- Scientific monitoring of fisheries (SMP-07).

The outputs will also be used to determine whether the termination criteria for this OMP have been achieved.

2.3 Relevant environmental data

TEO has used pre-existing information to determine the fauna that may reasonably be expected to occur within the EMBA, including distribution, seasonality and density.

TEO has also considered the potential effects of exposure to hydrocarbons on these fauna in the hydrocarbon spill risk assessments supporting the Cliff Head development and associated activities. Refer to the hydrocarbon spill risk assessments in the relevant Environment Plans.

Existing environmental data relevant to this OMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.4 Initiation Criteria

The initiation criteria for implementation of OMP-04 comprise:

- Level 2 or Level 3 hydrocarbon spill (as determined by OSCP / OPEP).

2.5 Termination Criteria

The termination criteria for this OMP comprise:

- Confirmation that source is controlled

AND

- The incident response has been terminated by the Incident Management Team (IMT)

  OR

- The information acquired by implementation of this OMP no longer informs decision making by the IMT

  OR

- Implementation of SMPs supersedes this OMP:
  - SMP-05 – Scientific monitoring of seabirds
  - SMP-06 – Scientific monitoring of sea lions, cetaceans and turtles
  - SMP-07 – Scientific monitoring of fisheries resources.

3 Methodology

3.1 Monitoring strategy

Wildlife within the EMBA will vary in their responses to spilled oil, as some taxonomic groups are more susceptible than others. A qualitative assessment of susceptibility to different spilled hydrocarbon fractions is provided in Table 1. Additionally, monitoring techniques that are effective for some groups may not be effective for others.

Additionally, in order to adequately inform the operational response in a timely manner, wildlife monitoring needs to be conducted rapidly and the results communicated to the IMT quickly. As such, the monitoring strategy used to undertake OMP-04 relies on survey techniques that can cover large areas quickly. More detailed, fine scale understanding of the effects of spilled hydrocarbons on wildlife will be obtained by the implementation of SMP-05, SMP-06 and SMP-07.

Table 1 – Qualitative assessment of susceptibility to spilled oil fractions

Taxa	Hydrocarbon phases		
	Surface	**Entrained**	**Dissolved**
Cetaceans	Moderate	Low	Low
Pinnipeds	High	Moderate	Low
Reptiles	Moderate	Low	Low
Seabirds and migratory shorebirds	High	Low	Low
Sharks and rays	Low	Low	High
Fishes	Low	Moderate	High
Invertebrates	Low	Low	High

3.2 Sampling design

Monitoring during OMP-04 will consist of surveys of wildlife to determine:

- The wildlife present within the area affected by the spill, including:
  - Any evidence of effects of oil contamination (e.g. oiling, carcasses)
- Wildlife within the spill trajectory that may be at risk
- The numbers of animals that have been affected, or are at risk of being affected, by the spilled oil.

The data collected during implementation of OMP-04 may contribute to the data collected and analysed in SMP-05, SMP-06 and SMP-07 (if implemented).

When undertaking monitoring of cetaceans, consideration should be given to the objectives requirements of Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations) – Interacting with cetaceans and whale watching.

The Australian National Guidelines for Whale and Dolphin Watching 2017 (Department of the Environment and Energy 2017) provided advice on compliance with Part 8 of the EPBC Regulations.

Approach distances are also detailed for WA State waters under the Biodiversity Conservation Regulations 2018, Part 5, Division 2.

Note that persons undertaking spill response actions consistent with the arrangements of the National Plan for Maritime Environmental Emergencies (the National Plan) (Australian Maritime Safety Authority 2014), the Commonwealth Minister for the Environment has released a statement that the Minster may exempt persons from the requirements of Section 158 and 303A of the EPBC Act.

3.2.1 Aerial surveys

Aerial surveys may utilise observers on rotary or fixed wing aircraft to monitor wildlife, particularly large animals at or near the surface such as cetaceans. Aerial surveys have several advantages and disadvantages relative to other methodologies:

- Advantages
  - Can rapidly cover large areas
  - Suitable for observing large fauna such as cetaceans
  - Can concurrently survey for hydrocarbons (e.g. surface slicks, shoreline contact etc.)
  - Easier to avoid recounts than other survey methods (i.e. counting the same individual animal more than once)
- Disadvantages
  - Cannot recover carcasses
  - Not suitable for observations of smaller fauna (e.g. birds, fishes)
  - Observations restricted to animals at or near the surface
  - Aircraft endurance may limit observation time.

The nearest mainland airfield to the Cliff Head Alpha platform is Dongara Airport (IATA code: DOX; ICAO code: YDRA), located ~11 NM to the north-north-west of the platform, and 1.2 km south of Dongara on Kailis Drive. The airport is operated by the Shire of Irwin. It has a single sealed runway and supports rotary and fixed-wing aircraft.

UAVs may be considered as an aerial platform for spill observations; particular attention should be paid to safety if operating UAVs concurrently with manned aircraft.

Experienced aerial observers with taxonomic skills should be utilised where practicable, however monitoring should not be delayed if experienced observers are not readily available.

Aerial observation should be reported on data sheets outlining the following:

- Identification (to lowest practicable taxonomic resolution)
- Behaviour / activity (e.g. feeding, transiting, loitering/milling etc.)
- Location
- Evidence of oil exposure.

Aerial surveys for wildlife should be conducted concurrently with other OMPs where practicable, particularly OMP-01 – Oil Distribution Monitoring (4716-HS-H0114-01). Observations of wildlife should be made within a fixed corridor width. This width will be a function of aircraft altitude and the observer's field of view from the aircraft. Corridor width should be used in conjunction with transect length to estimate the area surveys. This area, in conjunction with counts of individual wildlife, can be used to estimate the density of animal per unit of area (e.g. individuals per km^2).

When conducted in conjunction with aerial monitoring for OMP-01, counts should be conducted along transects used to monitor for hydrocarbons. Where aerial surveys for marine fauna are independent of other OMPs, surveys should be carried out along pre-determined transects extending from the shoreline to beyond the area affected by the spill. Transects should be clearly recorded (e.g. as a flight track), along with the start and end times / positions, weather observations, sea state and visibility.

3.2.2 Vessel-based surveys

Vessels will be used to undertake spill surveillance, with vessels mobilised through existing service providers either from vessels on site, Port Denison (Dongara) or Geraldton. The nearest mainland port to the Cliff Head Alpha platform is Port Denison, which is located ~12 NM to the north-north-west of the platform.

Vessel-based surveys have several advantages and disadvantages relative to other methodologies:

- Advantages
  - Long endurance in the field
  - Suitable for observing a range of fauna sizes
  - Can concurrently survey for hydrocarbons (e.g. surface slicks, shoreline contact etc.)
  - Can collect floating carcasses (e.g. fish kills, birds)
- Disadvantages
  - Limited field of view restricts area that can be sampled reliably
  - May alter animal behaviour (e.g. wildlife attraction to or avoidance of vessel)
  - Observations restricted to animals at or near the surface
  - Relatively slow compared to aerial surveys.

Vessels are constrained in their ability to detect wildlife given the relatively small area that can be observed when compared to aerial surveillance. This can be mitigated by mobilising multiple vessels to undertake visual observation, particularly where aerial surveillance is not available (e.g. immediately following a spill prior to mobilisation of aerial platforms). Observations are typically best made from a high vantage point on the vessel, such as the bridge or flybridge.

Vessel-based observation should be reported on the DBCA F1-1 Oiled Wildlife Reconnaissance: Observation Record Appendix A) outlining the following:

- Identification (to lowest practicable taxonomic resolution)
- Behaviour / activity (e.g. feeding, transiting, loitering/milling etc.)
- Location
- Evidence of oil exposure.

When observations are made from vessels undertaking response activities, observations of wildlife should be made opportunistically and should not interfere with the response operations. When conducted in conjunction with vessel-based monitoring for OMP-01, counts should be concurrent with monitoring for hydrocarbons. Where vessel-based surveys for marine fauna are independent of other OMPs, surveys should be carried out along pre-determined transects extending from near the shore to beyond the area affected by the spill. Transects should be clearly recorded (e.g. as a position track log), along with the start and end times / positions, weather observations, sea state and visibility.

3.2.3 Shoreline surveys

Shore based surveys can be used to monitor wildlife that routinely occur on shorelines, such as seabirds, shorebirds and Australian sea lions. These fauna are noted as being particularly vulnerable to the effects of oiling due to:

- Loss of insulation properties of feathers or fur
- Ingestion of oil during preening or grooming
- Associated with surface waters (and hence surface slicks) during feeding or breathing / haul out.

Shoreline assessments of wildlife should be carried out in conjunction with OMP-03 – Shoreline Assessment (4716-HS-H0114-03) where practicable. Identification of shorelines affected by hydrocarbons will be determined by OMP-01 – Oil Distribution Monitoring (4716-HS-H0114-01). The IMT should use the information provided in OMP-01 to designate shoreline sectors with consideration to the survey resources available (i.e. transport, personnel).

Mainland shorelines can be accessed either by vehicle (e.g. 4 wheel drive) or by vessels. The shorelines of offshore islands can be accessed by vessel.

During the shoreline assessment, any carcasses present should be examined and, where practicable collected for examination by a veterinarian (or suitably experienced expert). Carcasses may arise from wildlife dying onshore (e.g. birds dying at roosting areas) or dying at sea and being washed ashore (e.g. cetaceans, fish kills). All carcasses should be counted, photographed in situ and observations recorded on data sheets. Carcasses should be securely stored in heavy duty plastic bags, clearly labelled and delivered to wildlife management agency staff as soon as practicable. This should be done regardless of whether the carcass has visibly been affected by oil. Note that the presence of oil on a carcass does not necessarily mean the oil was the cause of death (e.g. a floating carcass resulting from non-oil related mortality may encounter surface slicks as sea prior to washing ashore).

3.2.4 Fisheries

Direct observation of fisheries resources is operationally difficult and time consuming during the spill response phase. As such, direct observations of fisheries resources will consist of opportunistic visual observations during aerial, vessel-based or shoreline monitoring. Direct monitoring is expected to consist of observations of freshly killed fish carcasses, either floating or stranded onshore. Where fish carcasses are observed, observations should be recorded (e.g. evidence of oil contamination, general condition), along with an indicative count (either total numbers of carcasses or a density within a given area), the time and the location.

Indirect monitoring of fisheries resources will be carried out by monitoring the landings of fish resources at access nodes (e.g. Geraldton and Port Denison). Landed fish should be observed for evidence of oil contamination, such as tainting or surface oiling. More detailed assessments of fisheries resources are described in SMP-07 – Scientific monitoring of fisheries resources (4716-HS-H0114-17).

Oil contamination of fishing ear, such as baited traps, nets and lines can also be obtained through discussions with fishers when inspecting fish landings.

3.3 Data management

3.3.1 Field data management

Field data will be recorded on data sheets during monitoring and communicated to IMT via communications channels (telephone, email, radio, email). The IMT will document all relevant information at the incident control centre as per the incident communications arrangements in the OSCP / OPEP.

Digital field data (e.g. photographs) should be downloaded as soon as practicable following retrieval of the instrument and backed up onto independent storage (e.g. portable hard drives). Photographs should be named and stored using a system that clearly links images to sites and facilitates storage, retrieval and back up. Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

3.3.2 Office data management

All communications with the field team and the IMT will be recorded. All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage.

All data sets will be accompanied by a metadata summary (refer to Cliff Head Project Operations Overarching OSMP (4716-HS-H0114) for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

3.3.3 Data Analysis

Data provided to the IMT will be assessed and used to inform spill response operations. This information will also be used to inform the design of SMPs.

4 Reporting

4.1 Injured/oiled wildlife

If an operational monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly notify the IMT[1] and seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

4.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance, etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other OMPs or SMPs
- Reports detailing the impacts (if any) on significant fauna as a result of a hydrocarbon spill. Reports should contain descriptive statistics of data collected and suitable comparisons between data sets (e.g. ongoing monitoring, reference and baseline data). Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Data from other OMPs and SMPs that may inform data analysis (e.g. spatial extend of hydrocarbon contamination) should be considered, where applicable. Data analysis should also consider the termination criteria for the OMP.

[1] The IMT is responsible for reporting/notifying regulators and management agencies of the spill and spill-related impacts on wildlife.

5 Pre-mobilisation Activities

The following should be considered prior to mobilising resources to implement this OMP in the field.

5.1 Personnel

In addition to the generic staff requirements described in the Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (OSMP) (4716-HS-H0114), staff required to implement OMP-04 should hold the following qualifications and competencies:

- Senior marine scientist(s) – to advise the IMT on the implementation of the program in the field
- Marine scientist(s) – carry out field monitoring under the direction of the IMT (note that where scientists are unavailable, other response personnel should carry out the tasks for this OMP)
- Environmental management agency staff (or their delegate e.g. veterinarian) or carcass inspection (if required).

All personnel conducting observations and wildlife should have suitable training on species identification and survey procedures/techniques.

Access to wildlife sites such as seabird rookeries and sea lion haul outs may require vessels, aircraft or vehicles and therefore, additional qualifications in relation to these may be required.

Note that, where practicable, personnel that have multiple competencies should fulfil more than one role to increase the efficiency of the OMP implementation.

5.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for OMP-04:

- Vehicles for accessing survey areas; may include vessels, aircraft or unmanned aerial vehicles (UAV) suitable for use as observation platforms, as required
- Video cameras, storage media and batteries (with spares)
- Digital still and video cameras (optionally with global positioning system (GPS)), storage media and batteries (with spares)
- GPS
- Communications (e.g. mobile or satellite telephone, radios)
- Digital camera(s) (including spare memory card and battery)
- Large heavy duty plastic bags
- Latex gloves
- Hard copy data sheets for recording observations
- Suitable office computer equipment for video and still image analysis and storage (including software)
- Vessel(s) suitable for deployment
- Video camera(s) (including spare memory cards and batteries).

5.2.1 Preparation

The following activities will need to be undertaken, to ensure equipment is in working order, prior to mobilisation to the field:

- Develop sampling program incorporating available existing data (Section 2.3)
- Liaise with wildlife management agencies (e.g. DCCEEW, DBCA) to determine permitting requirements for carcass collection and access to offshore island nature reserves. The Biodiversity Conservation Regulations 2018 provides licensing exemption for caring/protecting native fauna. DBCA Wildcare helpline has means to contact Licensing Officers afterhours

- Confirm equipment resources and availability to implement the sampling design as per the monitoring program
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA20).

5.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 5.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Procure and assemble field consumables and equipment (refer to Section 5.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Develop and implement Job Hazard Analysis (JHA) and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (Section 2.3)
- Arrange transportation for collected samples from field to laboratory

Refer to the Cliff Head Project Operations Overarching Oil Spill Monitoring Plan (4716-HS-H0114) for additional information on logistical considerations.

6 References

Australian Maritime Safety Authority, 2014. National plan for maritime environmental emergencies. Australian Maritime Safety Authority, Canberra.

Department of the Environment and Heritage, 2005. Australian national guidelines for whale and dolphin watching 2005. Department of Environment and Heritage, Canberra.

Commonwealth of Australia (2014). EPBC Act 1999, Section 303A(3) Exemption Statement of Reasons (Maritime Environmental Emergencies). Dated 6 March 2014. Accessed online: https://www.environment.gov.au/epbc/notices/pubs/140306-section-303a-reasons-exemption.pdf

Appendix A F1-1 OILED WILDLIFE RECONNAISSANCE: OBSERVATION RECORD

F1-1 OILED WILDLIFE RECONNAISSANCE: OBSERVATION RECORD

Incident name:	**Page** __________ **of** __________ **for this location and date**
Division:	**Date:**
Location Name:	**Time Start:** **Time End:**
Sector: **Segment:**	**Observer/s:**
GPS Start: **GPS End:**	**Survey method (circle)** foot land vehicle sea vessel aircraft

1. **FAUNA OBSERVATIONS** Complete a line entry per individual animal or groups of the same species in the same location.

Species Common Name (if known) or taxon key [A]	No. of Animals			No. oiled (or % if large numbers)	Behaviour [B]	GPS Coord. Lat/Long	Fine scale Location [C]	Animal status (e.g. sex, age, size) and Other Comments
	Live	Dead	Total					

CONTINUED OVERLEAF

[A] **B=bird (BS = seabird; BSh = shorebird; BW = wading bird; BO= other); M = mammal (MC= cetacean; MP= pinniped [seal or sealion]; MO= other); R = reptile (RT = turtle; RO = other); O = other**

[B] **Behaviour Key (use as many as required): F** = foraging/feeding; **FL** = flying; **M** = mating; **N** = nesting; **R** = resting/roosting; **S** = swimming; **W** = wading; **WK** = walking

[C] **e.g. shoreline, surf zone, dunes, concealed in vegetation**

F1-1

Appendix A.5 OMP-05 – Response Strategy Monitoring (4716-HS-H0114-05)

OMP5 - Response Strategy Monitoring

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-05

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This OMP5 - Response Strategy Monitoring for the Cliff Head Project is a controlled document.

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

Bryce Donaldson
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This OMP5 - Response Strategy Monitoring shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This OMP5 - Response Strategy Monitoring has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

1 References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP03 – Shoreline Assessment
4716-HS-H0114-04	OMP04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP07 - Scientific monitoring of fisheries resources

2 Term Definitions and Abbreviations

Term or abbreviation	Definition
CHA	Cliff Head Alpha
ECR	Emergency Control Room
IMT	Incident Management Team
IMTL	Incident Management Team Leader
NEBA	Net Environmental Benefit Analysis
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
SEC	Site Emergency Controller
TEO	Triangle Energy (Operations) Pty Ltd

3 Rationale

The purpose and aim of Operational Monitoring Plan 05 (OMP05) is to monitor the effectiveness and appropriateness of scale of the response strategies implemented during the operational response to a hydrocarbon spill. The response strategies TEO may implement are detailed in the Cliff Head Alpha (CHA) Operations Oil Spill Contingency Plan (OSCP) (10HSEQENVPL02) or Cliff Head Alpha Operations Oil Pollution Emergency Plan (OPEP) (10HSEQENVPL15). The strategies include:

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

The effectiveness of a given response strategy will depend on the nature of the spilled oil, the distribution and weathering of the oil, the environmental receptors affected or at risk, and the resources available to implement the response strategy. The implementation of response strategies that are ineffective or result in environmental disturbance may result in greater environmental harm than the spilled oil. By monitoring the effectiveness of response strategies, TEO will verify that the response strategies implemented, or under consideration for implementation, are effective and result in a net environmental benefit.

TEO has developed a Net Environmental Benefit Analysis (NEBA) process (detailed in OSCP / OPEP for the Cliff Head development). The NEBA is used as a tool to assist in determining which response strategies are considered to result in a net environmental benefit (i.e. the environmental benefit exceeds the environmental “cost”).

3.1 Objectives

The objectives of OMP05 are to:

- Provide an ongoing assessment of the effectiveness of the response strategies and the net environmental benefit of the response
- Provide the Incident Management Team (IMT) with sufficient information on the effectiveness of response strategies to inform decision making on the initiation, continuation and termination of response strategies.

4 Decision-making inputs and outputs

4.1 Inputs from other plans

In order to inform the initiation and design of this OMP, the following inputs will be required from the OSCP / OPEP and other OMPs:

- Release location
- Release time
- Hydrocarbon type (either vessel fuel or Cliff Head crude)
- Estimated volume of spilled hydrocarbon Current and previous distribution of hydrocarbons from the spill (OMP01)
- NEBA outcomes (from OSPC / OPEP)
- Current response strategies implemented (from IMT)
- Operational information on response strategies (routinely reported to IMT during response).

4.2 Outputs to other plants

The information obtained during implementation of this OMP will assist the IMT in determining:

- Whether the current response strategies are effective and are reasonably considered to result in a net environmental benefit
- Whether the current response strategies should be continued or terminated.

4.3 Relevant environmental data

Existing environmental data relevant to this OMP are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

4.4 Initiation criteria

The initiation criteria for implementation of OMP05 comprise:

- Level 2 or Level 3 hydrocarbon spill (as determined by OSCP / OPEP).

4.5 Termination criteria

The termination criteria for this OMP comprise:

- Confirmation that source is controlled
  AND
- The incident response has been terminated by the IMT
  OR
- The information acquired by implementation of this OMP no longer informs decision making by the IMT.

5 Methodology

5.1 Monitoring strategy

The response strategies, along with the maximum credible spill scenarios for the Cliff Head development are provided in Table 1 . Each of these response strategies has different objectives, environmental benefits, environmental risks and implementation requirements, which are detailed in the OSCP / OPEP for the Cliff Head development. As such, each response strategy should be assessed separately when monitoring response strategies.

The NEBA framework developed by TEO is described in the OSCP / OPEP. This NEBA framework provides for an assessment of the negative and positive impacts of each of the response strategies. The ongoing use of the NEBA framework is the primary means by which the effectiveness of the response strategies will be determined during spill response.

NEBA assessments should incorporate information from the response personnel in the field. The NEBA should be reassessed whenever there are material changes (i.e. those that may alter the response strategy) reported by field personnel.

Response strategy monitoring can only be undertaken for the strategies that have been implemented. Note that the implementation of response strategies is distinct from the implementation and termination of OMPs and SMPs.

Table 1 – Response strategies for hydrocarbon spills based on preliminary NEBA (refer to OPEP in relation to Cliff Head development)

Response strategy	Deck spillages (CHA and vessels) (<2 m^3)	Pipeline leak (continuous small leak – 21 days) (97 m^3 Cliff Head crude)	Topside process leak (21 days) (84.3 m^3 Cliff Head crude)	Vessel spill (500 m^3 marine diesel)
Source control	Recommend	Recommend	Recommend	Recommend
Monitor and evaluate	Recommend	Recommend	Recommend	Recommend
Offshore containment and recovery	No	Consider	Consider	Consider
Shoreline protection and deflection	No	Consider	Consider	Consider
Shoreline clean-up	No	Consider	Consider	Consider
Oiled wildlife response	No	Consider	Consider	Consider

5.2 Sampling design

All response strategies should be assessed by comparing the identified need for the response strategy (based on the nature and scale of the spill and the outcomes of the NEBA assessment) and the availability of resources to implement the spill response. The ability of the resources mobilised during the response should be compared to the needs identified during the NEBA assessment for all response strategies. This comparison should be considered by the IMT during the response phase to verify that the resources mobilised during the response are adequate.

Suggested metrics for assessing effectiveness of response strategies are provided in Appendix A.

5.2.1 Source control

Source control is a primary response strategy in the event of any hydrocarbon spill in relation to the Cliff Head development. The method of source control will vary depending on the nature of the release however the objective is the same regardless of the type of spill – to control the source of the hydrocarbon release. Source control will stop, or reduce the rate, of the release into the environment.

Evaluation of the source control response strategy will consider:

- The time taken to control the source
- Estimation of the volume of oil released
- The effectiveness of the source control (e.g. completely controlled the release, partially controlled the release, ineffective in controlling the release)
- The endurance of the source control (e.g. how long is the control expected to be effective for, what additional works need to be undertaken to permanently correct the release).

It is expected that, from an environmental perspective, source control will result in a net environmental benefit under all circumstances.

5.2.2 Monitor and evaluate

Monitor and evaluate is a primary response strategy that will be implemented during all oil spill response incidents. It is expected that, from an environmental perspective, source control will result in a net environmental benefit under all circumstances. The objectives of the monitor and evaluate strategy are to:

- maintain situational awareness
- obtain information to inform the responses plan
- understand the likely fate and trajectory of the spill.

Refer to the OSCP / OPEP and OMP01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column (4716-HS-H0114-01) for additional information on the monitor and evaluate response strategy.

Evaluation of the monitor and evaluate response strategy will consider:

- Time taken to implement components of the response strategy (e.g. aerial observers, trajectory modelling)
- The ability for the IMT to track the spill based on information from the field
- Effectiveness of trajectory assessments in identifying environmental resources at risk
- Effectiveness at directing other response strategies where implemented (e.g. by identifying concentrations of floating oil suitable for offshore containment and recovery)
- Effectiveness at identifying the environmental resources that have been affected by the spill.

A number of the points above can only fully be considered following termination of the spill response. However, partial consideration of the effectiveness of the monitor and evaluate response should be carried out routinely to guide the spill response.

5.2.3 Offshore containment and recovery

Implementation of offshore containment and recovery may be carried out to reduce the volumes of floating oil at sea, which in turn reduces the likelihood of shoreline contact, or contact with sensitive receptors. Containment and recovery is most effective against surface hydrocarbons and is ineffective against dissolved and entrained hydrocarbons. Containment of spilled oil will typically be done by the deployment of booms, which are effective on surface slicks and near surface entrained hydrocarbons.

Evaluation of the offshore containment and recovery response will consider:

- Effectiveness of booms in containing surface hydrocarbons
  - Boom effectiveness is dependent on boom characteristics, sea state (rougher seas decrease effectiveness) and surface oil thickness. On site observers should monitor and report on the sea state, the volume of oil retained and the amount of surface oil escaping booms (refer to OMP01 - Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column (4716-HS-H0114-01) for information on estimating surface oil volumes).
- The efficiency of hydrocarbon recovery
  - Recovery of spilled hydrocarbons from within the boom (e.g. via skimmers or absorbents). Recovered hydrocarbons are typically stored onboard vessels in tanks. The volume of recovered oil can be estimated based on the tank contents. By comparing the volume of recovered oil in tanks to the volumes retained in the booms, an estimate of recovery efficiency can be made.
  - Volumes of recovered hydrocarbons can be compared to the estimated spill volume and weathering characteristics to provide an estimate of the volume of recovered hydrocarbons.
- The management of wastes generated during the offshore recovery.
  - Management of recovered oil includes the management of liquid (e.g. recovered oil and oily water) and solid wastes (e.g. used absorbents). Waste materials may be treated in several ways, including incorporation into refining streams, incineration, cleaning of contaminated material and managed landfill. Waste management details are provided in the OSCP / OPEP. The volumes of waste material generated and the fate of contaminated material should be recorded during the response.
  - Waste management can represent a bottleneck during a spill response; when waste storage capacity is reached, additional recovery of oil / oily wastes cannot be handled adequately. The capacity of the waste storage and handling facilities should be monitored regularly during the spill response and communicated to the IMT.

5.2.4 Shoreline protection and deflection

Shoreline protection and deflection is intended to prevent spilled oil from stranding on the shoreline. This is intended to be carried out by the deployment of booms, as per the offshore containment and recovery phase. However, unlike offshore containment and recovery, where booms are intended to concentrate surface hydrocarbons to facilitate removal, shoreline booms are primarily intended to protect particularly sensitive shoreline resources, with the concentration of hydrocarbons to facilitate removal being a secondary objective. Concentration of hydrocarbons may be in a surface area or to an area of shoreline that is considered less sensitive to facilitate recovery or clean-up of spilled oil. The assessment of the shoreline protection and deflection should consider:

- Selection of priority protection areas
  - The selection of the areas which were intended to be protected should be assessed both during and following the spill response. This assessment should consider the manner in which the priority protection areas were selected (including existing environmental data and the NEBA process described in the OSCP / OPEP), the availability of protect and deflect resources (e.g. booms, personnel), logistical constraints (e.g. shoreline access) and the feasibility of the booms being effective (e.g. booms on high energy shorelines such as wave exposed beaches are likely to be less effective than low energy environments such as harbours).
- Effectiveness of booms in containing surface hydrocarbons (refer to Section 5.2.3)
- Effectiveness of booms in deflecting hydrocarbons and avoiding shoreline contact
  - The effectiveness of booms in deflecting hydrocarbons and avoiding shoreline contact can be assessed by undertaking an assessment of the nature and volume of oil stranded on a shoreline, as well as the volume of oil recovered / deflected. Refer to OMP03 – Shoreline Assessment (4716-HS-H0114-03) for information and methodologies for assessing shoreline contact. This should be carried out concurrently with the assessment of the effectiveness of booms.
- The efficiency of hydrocarbon recovery (refer to Section 5.2.3)
- The management of wastes generated during the offshore recovery (refer to Section 5.2.3).

5.2.5 Shoreline clean-up

Shoreline clean-up is intended to minimise the impacts to sensitive shorelines from accumulated stranded oil (either from surface slicks or stranding of entrained oil). Shoreline clean-up techniques may vary depending on the nature and scale of shoreline contamination, shoreline type, shoreline accessibility and resource availability. Shoreline clean-up can result in considerable direct disturbance to the environment and can generate large volumes of oiled waste material that requires disposal.

The assessment of the effectiveness of shoreline clean-up should also consider the results of SMP03 – Scientific monitoring of shoreline and intertidal benthos (4716-HS-H0114-13).

The assessment of the effectiveness of shoreline clean-up should consider:

- The selection of the shoreline clean-up technique
  - There are a range of shoreline clean-up techniques that may be implemented (e.g. pressure cleaning, mechanical and manual collection, washing etc.), each of which may have environmental impacts and benefits. The NEBA assessment should document the considerations to implement shoreline clean-up and, if implemented, the methods used, along with the consideration of the benefits and impacts of the methods considered.

- The selection of areas for clean-up
  - The effectiveness of the shoreline clean-up response relies on deploying resources where they can be most effectively used. In assessing the effectiveness of shoreline clean-up, the process used to identify and prioritise areas for shoreline clean-up should be considered. The NEBA assessment should consider the benefits and impacts for a given shoreline, including consideration of the shoreline type and level of oiling. Refer to OMP03 – Shoreline Assessment (4716-HS-H0114-03) for information and methodologies for assessing shoreline contact.
- The efficiency of hydrocarbon recovery (refer to Section 5.2.3)
- The volume of wastes generated during the offshore recovery (refer to Section 5.2.3).

5.2.6 Oiled wildlife response

The oiled wildlife response strategy is intended to maximise the protection of, and minimise impacts to, wildlife either from spilled oil or spill response activities. Oiled wildlife response activities will vary depending on the nature and scale of the spill, the wildlife affected or at risk, and the availability of resources. Where practicable, the assessment of the oiled wildlife response should be incorporated into OMP04 – Wildlife impact monitoring (4716-HS-H0114-04). Assessment of the oiled wildlife response should include:

- Effectiveness of hazing
  - Where hazing of wildlife is carried out to disperse wildlife away from the spill, an assessment of the hazing should be carried out as much as practicable, including:
    - The number or proportion of wildlife hazed – counts of the numbers of animals present prior to hazing should be made.
    - The portion of wildlife returning to an area after initial hazing – counts of the numbers of animals returning after hazing should be made.
- Effectiveness of collection of animals, including:
  - Pre-emptive capture to prevent animal oiling – counts of the number of animals present prior to attempting capture, along with the number of animals captured should be made.
  - Post-oiling capture to facilitate cleaning and rehabilitation – counts of the number of live oiled animals captured for cleaning, rehabilitation and release should be made.
  - Collection of carcasses for assessment of oil-induced mortality – a record of all animal carcasses recovered during the response should be maintained.
- Monitoring of animals, including:
  - During holding and cleaning operation prior to release. Animals should be monitored for general condition and mortality.
  - Following release of cleaned animals. In particular, re-oiling of previously cleaned animals and mortality following cleaning should be monitored. This should be considered in the development of scientific monitoring plans to monitor wildlife, including SMP05 – Scientific monitoring of seabirds and shorebirds (4716-HS-H0114-15) and SMP06 – Scientific monitoring of sea lions, cetaceans and turtles (4716-HS-H0114-16). Accurate monitoring of re-oiling may require some form of marking or record (e.g. temporary paint, banding, tagging, photo identification) be made for all animals released.

5.3 Data management

5.3.1 Field data management

Field data management requirements are detailed in the OSCP / OPEP and the relevant OMPs. No additional field data specific to OMP05 are required.

5.3.2 Office data management

All communications with the field team and the IMT will be recorded as described in the OSCP / OPEP. All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage.

5.3.3 Data Analysis

Data provided to the IMT will be assessed and used to inform spill response operations. The IMT will consider the outcomes of OMP05 in managing the implementation of spill response strategies and the use of available resources.

Data analysis should be reported in all post-spill assessments, with lessons learned communicated and procedures updated accordingly.

6 Reporting

6.1 Injured/oiled wildlife

If an operational monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly notify the IMT and seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

6.2 Data reporting

The assessment of the spill response should routinely be recorded by the IMT during the spill response. This will include initial and ongoing NEBA assessment, communications from the SEC and the decision making from the IMT.

An assessment of the effectiveness of response strategies should also be carried out following termination of the spill response. Any lessons learned should be communicated to relevant spill response participants.

Reporting to stakeholders such as incident reporting to regulatory authorities should incorporate an assessment of the effectiveness of response strategies.

7 Pre-mobilisation activities

No specific pre-mobilisation activities are required to implement OMP05; all of the resources and activities needed to implement this OMP are described in the OSCP / OPEP and other OMPs.

7.1 Personnel

No specific personnel are required to implement OMP05; all personnel, roles and responsibilities are contained within the OSCP / OPEP and other OMPs.

7.2 Equipment

No specific equipment is required to implement OMP05; all equipment requirements needed to implement this OMP are described in the OSCP / OPEP and other OMPs.

While the following points are contained in the OSCP / OPEP, particular attention should be made to:

- The establishment of clear lines of communication between the IMT and the Incident Management Team Leader (Perth Incident Controller) (IMTL)
- The provision of necessary equipment in the Emergency Control Room (ECR), including communications equipment (including records of communications), NEBA tools (refer to OSCP / OPEP) and maps / geographic information systems
- Documentation of communication and decision making by the IMT during the response.

7.3 Logistics

No specific logistical considerations are required to implement OMP05; all logistical requirements to implement this OMP are described in the OSCP / OPEP and other OMPs.

While the following points are contained in the OSCP / OPEP, particular attention should be paid to:

- The availability of spill response resources
- The management of waste materials (e.g. recovered oil, oily wastes)
- Details on the mobilisation of response personnel and equipment.

Appendix A Suggested metrics for response strategy assessment

Suggested metric
Source control
Effectiveness of source control (completely effective, partially effective, ineffective)
Volume of oil released
Monitor and evaluate
Accuracy of position reports
Time taken to communicate field observations to IMT
Number of observers at a given time
Offshore containment and recovery
Volume of oil recovered per skimmer per day
Volume of oil retained
% of observed surface oil retained and / or recovered
Shoreline clean-up / shoreline protection and deflection
Volume of oil and oiled debris recovered per person/hour/day
Volume of oil and oiled debris stockpiled and awaiting collection at end of shift
Area of impacted shoreline cleaned-up, per person-hour/day
Area of shoreline adversely impacted from response activities (e.g. oil-waste contamination), per hour/day
Area of clean-up shoreline re-contaminated by the oil spill slick, per hour/day
Oiled wildlife response
% of oiled wildlife recovered
% of hazed animals returning to oiled areas
Number of oiled wildlife recovered alive / deceased
Mortality of oiled wildlife during cleaning
Survival rate of released treated wildlife

Appendix B Scientific Monitoring Plans

Appendix B.1 SMP01 - Scientific monitoring of hydrocarbons in marine waters (including weathering) (4716-HS-H0114-11)

SMP-01 - Scientific Monitoring of Hydrocarbons in Marine Water (including Weathering)

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-11

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-01 - Scientific Monitoring of Hydrocarbons in Marine Water (including Weathering) for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This SMP-01 - Scientific Monitoring of Hydrocarbons in Marine Water (including Weathering) shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-01 - Scientific Monitoring of Hydrocarbons in Marine Water (including Weathering) has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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Table of Contents

1 References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

2 Term Definitions and Abbreviations

Term or abbreviation	Definition
ANZG	Australian and New Zealand Governments and Australian state and territory governments
BACI	Before–after Control-Impact
BTEXN	Benzene, toluene, ethylbenzene, xylenes (meta-, para- and ortho-xylene) and naphthalene
CHA	Cliff Head Alpha
CoC	Chain of custody
CRS	Coordinate Reference System
DO	Dissolved oxygen
EMBA	Environment that may be affected
GDA2020	Geodetic Datum of Australia 2020
GPS	Global positioning system
HAZID	Hazard identification workshop
HSE	Health Safety and Environment
HSEQ	Health, Safety, Environment and Quality
IMS	Invasive Marine Species
JHA	Job Safety Analysis
LOR	Limit of reporting
MGA	Mapping Grid of Australia
MGA	Map Grid of Australia
MSDS	Material Safety Data Sheets
NATA	National Association of Testing Authorities
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring program
PAHs	Polycyclic aromatic hydrocarbons
PIANO	*n*-paraffins, isoparaffins, aromatics, naphthalenes, andolefins
PPE	Personal Protective Equipment
QA/QC	Quality assurance / quality control
RFU	Raw fluorometry units
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
USB	Universal Serial Bus

3 Rationale

The rationale and purpose Scientific Monitoring Plan 01 (SMP-01) is to assess the concentrations of various hydrocarbon fractions in marine water, from which inferences about the nature of hydrocarbon contamination can be made. This information will inform investigations of cause/effect relationships between the hydrocarbon spill and impacts to environmental values and sensitivities.

SMP-01 is distinct from SMP-02 - Scientific monitoring of hydrocarbons in marine sediments (4716-HS-H0114-12).

3.1 Objectives

The objectives of SMP-01 are to:

- quantify the nature of hydrocarbons attributable to the spill over time. This data can subsequently be related to changes in the health and/or condition of key sensitive receptors potentially affected by spilled hydrocarbons, for the purpose of assessing the impact of the spill on environmental values and sensitivities.

4 Decision-making inputs and outputs

4.1 Inputs from other plans

In order to inform the initiation and design of SMP-01, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column (4716-HS-H0114-01))
- The predicted spill trajectory (OMP-01)
- Concentration of hydrocarbons in water from operational monitoring (OMP-01) and numerical modelling (OMP-02 – Oil Character and Fate Modelling (4716-HS-H0114-02)).

4.2 Outputs to other plans

Given the characteristics of a hydrocarbon spill (i.e. composition) affect how a spill interacts with environmental values and sensitivities, the outputs from this SMP are of relevance to all other SMPs in understanding hydrocarbon related impacts. The outputs will also be used to determine whether the termination criteria for this SMP have been achieved.

4.3 Key environmental receptors

Marine waters throughout the region are considered to be high quality, with few point sources of pollution. Water quality data collected by TEO indicates hydrocarbon levels in coastal waters in the vicinity of the Cliff Head operations are very low (typically below the laboratory limit of detection).

4.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

4.5 Initiation criteria

The decision to implement this SMP will be made by the Manager HSE & Regulatory (or their authorised delegate) based on the results of operational monitoring. The initiation criteria for implementation of this SMP comprise:

- Operational monitoring of hydrocarbons in water and sediment indicate that hydrocarbon levels are above threshold values (OMP-02). These thresholds are based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality ANZG 2018) 99% species protection level for hydrocarbons, as shown in Table 1.

Table 1 – Toxicant default guideline values for hydrocarbon fractions for marine water quality

Hydrocarbon fraction	Concentration (µg/L)
Benzene	500
Toluene	110
Cumene (isopropylbenzene)	20
Ethylbenzene	50
m-Xylene	50
Naphthalene	50
Anthracene	0.01
Benzo(alpha)pyrene	0.1
Flouranthene	1
Phenanthrene	0.6

4.6 Termination criteria

The decision to terminate this SMP will be made by the Manager HSE & Regulatory (or their authorised delegate) based on the results of this SMP. The termination criteria or this SMP comprise:

- No statistically significant difference in the concentration of hydrocarbons attributable to the spill between impact and reference sites.

5 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

5.1 Personnel

In addition to the generic staff requirements described in the Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program (OSMP) (4716-HS-H0114), staff required to implement SMP-01 should be suitably qualified and competent to perform the following responsibilities:

- Senior marine scientist(s) – to design the monitoring program and implement the program in the field
- Marine scientist(s) – to implement the SMP under the direction of senior marine scientist(s)
- Vessel staff – to assist in the deployment and recovery of sampling equipment.

All marine scientists deployed to the field work should be competent in and/or experienced in collecting hydrocarbon samples, water samples and water quality data.

5.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP, the following equipment is required for SMP-01:

- Chain of Custody (CoC) sheets
- Clean seawater for rinsing
- Cleaning agent (e.g. Decon 90)
- Coolers (including ice bricks) for sample transport
- Job Hazard Analysis (JHA)
- Laboratory address labels
- Large heavy duty plastic bags
- Material Safety Data Sheets (MSDS) for all chemicals
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Sample containers (including 10% contingency)
- Submersible hydrocarbon fluorometer
- Vessel(s) suitable for deployment
- Water quality profiler (e.g. CTD profiler) including dissolved oxygen
- Water samplers (e.g. bomb sampler, Niskin bottle, submersible pump).

5.2.1 Preparation

The following equipment preparation will be undertaken:

- Develop the monitoring design for the SMP in accordance with the principles in the overarching OSMP
- Confirm equipment resources and availability (e.g. number/type of water quality samplers, sampling containers, coolers, ice bricks) to implement the sampling design as per the monitoring program
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order and has been calibrated

- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

5.2.2 Calibration

Fluorometers and water quality profilers have calibration requirements. Pre-deployment calibration in accordance with the manufacturer's instructions should be carried out prior to use to ensure data quality.

5.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 5.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Assemble field consumables, blanks and equipment (refer to Section 5.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 4)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Co-ordinate National Association of Testing Authorities (NATA)-accredited laboratories to confirm availability, limits of detection, obtain sample analysis quotes and arrange provision of appropriate sample containers, CoC forms, coolers and ice bricks
- Confirm information on sampling holding times and requirements for collection and transport of water quality samples to analytical laboratories
- Develop and implement JHA and TEO Oil health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 5.2)
- Arrange transportation for collected samples from field to laboratory

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

6 Methodology

6.1 Monitoring strategy

SMP-01 will monitor water in offshore, near shore and onshore environments. Table 2 summarises the monitoring parameters that will be assessed to examine the presence, quantity and character of hydrocarbons in marine waters.

Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 2 – Environmental sensitivities, aspects and methodologies

Environmental sensitivity	Aspect	Methodology
Marine waters over identified resources at risk such as: • Reefs and shoals • Seagrass habitat • Macroalgae • Filter feeder habitat • Intertidal habitats (sandy and rocky shores) • Pelagic habitats	Hydrocarbon contamination of marine waters (from which weathering will be inferred) Water quality profile	Water quality profiler with hydrocarbon fluorometer Hydrocarbon concentrations in marine waters for laboratory verification of fluorometry results

6.2 Sampling design

SMP-01 will confirm the distribution of the spill and variation in the characteristics of the hydrocarbon over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP include:

- Vessel based marine water quality surveys.

As such, a series of sites would be expected to be selected based on whether they have been affected by the hydrocarbon spill (i.e. impact sites) or have not been affected by the spill (i.e. reference sites).

Where appropriate baseline data are available, consideration should be given to developing a beyond Before After Control Impact (BACI) monitoring program design (Underwood 1994, 1991), which monitors a range of reference and impact sites over time (i.e. a longitudinal study). Where robust, appropriate baseline data for impact sites are not available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory may be prioritised to obtain baseline data at impact sites prior to hydrocarbon exposure.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP for additional details.

6.2.1 Monitoring sites

Monitoring sites will consist of two types of site:

- Impact sites – sites which are known to have been exposed to spilled hydrocarbons

- Reference sites – sites which are known to have not been exposed to spilled hydrocarbons, but are otherwise similar to impact sites.

Note that sites may be further divided based on the level of hydrocarbon exposure (i.e. multiple levels within the exposure factor).

Impact and reference sites can be identified from the outputs of OMP-01, with impact sites drawn from areas known to be, or predicted to be, affected by spilled hydrocarbons. Reference sites can be selected in areas that are beyond the environment that may be affected (EMBA). In selecting reference sites, consideration of the uncertainty of the EMBA should be born in mind (i.e. TEO should be confident that the reference sites will remain unaffected by spilled hydrocarbons). The number of each will be determined by the nature of the actual spill event.

Care should be taken when selecting reference sites to ensure that they are comparable to impact sites. Refer to the overarching OSMP for more detailed discussion on the principles of monitoring program design.

6.2.2 Monitoring parameters

Table 3 outlines the parameters, methodologies and parameters that will be used for SMP-01.

Table 3 – Aspects, methodologies and associated parameters for SMP-01

Aspect	Methodology	Parameter
Hydrocarbon concentrations in marine waters	Water samples for hydrocarbons in marine waters for laboratory analysis In-situ instrument measurement of UV fluorometric data through the water column	Total recoverable hydrocarbons (TRH) Benzene, toluene, ethylbenzene and xylenes and naphthalene (BTEXN) Polycyclic Aromatic Hydrocarbons (PAH) Ultraviolet fluorometer data, Profile of aromatic hydrocarbons fluorescing through water column. Results will be based on Raw Fluorometer Units (RFUs) until calibration curve can be prepared identifying relationship between RFUs and laboratory data
Conductivity, temperature and dissolved oxygen	In situ instrument measurement through the water column using water quality profiler	Temperature (°C) Conductivity (~Salinity) Depth Dissolved oxygen (DO)

6.2.3 Monitoring frequency and duration

An initial round of sampling for this SMP should be implemented as soon as practicable following the initiation trigger being reached. The frequency of additional ongoing monitoring will be determined based on an assessment of the results of the OMPs and the preliminary results of this SMP.

Monitoring frequency should consider weathering of the spilled hydrocarbon, with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 4.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

6.3 Sampling procedure

6.3.1 Water quality surveys

If a surface slick is present (only expected in the initial day following a spill), a hydrocarbon-free area will need to be created adjacent to the vessel to reduce contamination of sampling equipment as it is lowered through the surface of the water. To do this, a surface free of hydrocarbons should be created. This can be done using a boom deployed from the vessel and surface hydrocarbons will be removed from within via absorbent pads (see Figure 1). While there may still be some trace amounts of hydrocarbons remaining, the majority of floating surface material will be removed via this method, allowing the sampling equipment to be lowered into the water with a reduced risk of contamination.

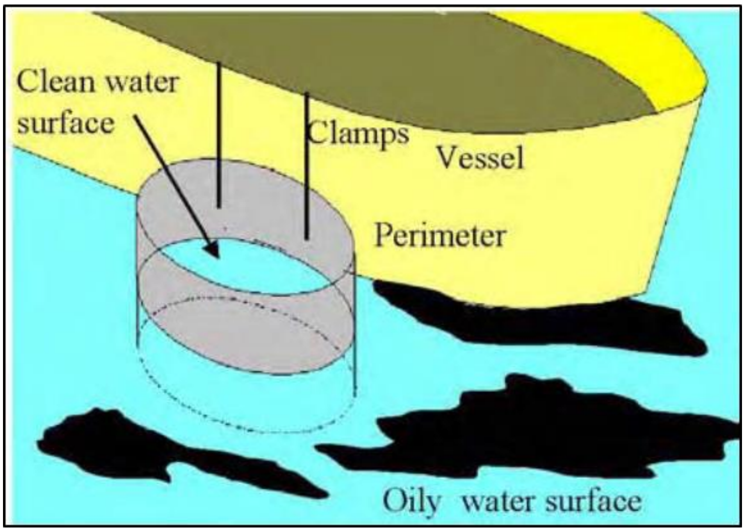

Figure 1 – Example deployment of a bottomless perimeter for clean water sampling

The distribution of hydrocarbons (if present) in the water column will be measured by deploying a fluorometer along with a water quality profiler (e.g. CTD). The fluorometer and water quality profiler will be deployed in situ initially and the data collected will be used to determine the depths where water quality samples will be collected. If the fluorometer does not indicate hydrocarbons being present in the water column, subsurface water samples should be collected at near surface, the middle of the water column and near the seabed. The water collection sampler will collect samples at depths where the fluorometer has indicated that hydrocarbons are present. Note that care should be taken to avoid sample contamination by a surface slick.

At each location the following protocol will be followed:

(1) Field observations, including, time, location and meteorological conditions, will be recorded on field observation sheets and entered into digital data storage as soon as practicable
(2) Latex gloves to be worn whilst handling water sampling equipment. Gloves should be changed between each water sampling location
(3) Potential anthropogenic contaminants (e.g. sun cream, smoking/smokers, sweat, hydrocarbons from exhaust gases, fuel or cleaning agents etc.) are to be avoided by the personnel in contact with the water sampling equipment The insides of the sample container lids will not come in contact with anything potentially contaminated (such as hands, gloves, work area or vessel). Hands cannot come into contact with the insides or lip of the bucket or sample bottles, the tip of the syringe or the syringe filters
(4) A water sample should be collected using a water sampling device and recovered to the surface
(5) Empty the contents of the water sampler into a clean bucket or volumetric flask (after rinsing the container with sample water three times)
(6) Sample water will be transferred into containers for hydrocarbon analysis (see Table 3). A syringe may be used to transfer the sample water to the sample bottles, but care must be taken that the outside of the syringe does not touch any other surface. The syringe will also need to be rinsed three times with sample water before any sample is transferred. For larger samples, a volumetric measuring cylinder may also be utilised with the same rinsing method

(7) Containers must be filled as full as possible to exclude air and avoid evaporative losses of light hydrocarbons.

After collection of samples at each site, the procedure below will be followed:

- Samples will be labelled according to instructions in Section 0
- All samples will be kept cool on ice or refrigerated to 4°C until delivery to the laboratory
- The water sampler is decontaminated (e.g. by cleaning with Decon 90 and rinsing with clean seawater) prior to collecting the next sample.

Analytical parameters, sample containers, storage requirements and holding times are summarised in Table 3. It is important to note that this information should be confirmed with laboratories, as holding times and limits of reporting may vary between service providers.

Table 4 – Summary of subsurface water sample testing, containers, storage and holding times

Sample Type	Parameter	Container	Storage	Holding Time
Hydrocarbon Samples	TRH/BTEXN	1 x 50 mL amber glass	Chill to 4 °C, zero head space	1 week
	PAH	1 x 100 mL amber glass	Chill to 4 °C, zero head space	1 week

6.3.2 Sample labelling

All samples should be pre-labelled or labelled immediately following sealing of the container with indelible marker. Sample containers will be clearly labelled with the following information as a minimum:

- Unique sample identification (ensure that the sample identification is clearly recorded in the field data sheet). This sample identification should be unique, unambiguous and clearly linked to the sampling site
- Analytical parameter(s)
- Sample collection time and date
- Project specific job number.

6.3.3 Sample transport and storage

Samples must be handled, stored and transported with care to avoid contamination. Samples should be collected and sent to the specified laboratory for analysis in accordance with holding times wherever practicable. Note that non-compliance with holding times and sample storage requirements may invalidate analytical results.

Samples should be packed securely into suitable size coolers using packing material and freezer blocks for delivery to each laboratory. CoC forms should be completed and accompany all analytical samples following collection. Whenever samples change hand (e.g. from field team to courier, from courier to analytical laboratory) the CoC should be updated to reflect this.

6.4 Data management

6.4.1 Field data management

Field observations will be recorded on data sheets during monitoring. Information will be recorded on each of data sheet, including, but not limited to:

- Date and time of sampling
- Model and serial number of in-situ monitoring instrument(s) deployed
- Sample site reference code/number
- Sample depth(s) and GPS position for each deployment

- Sample description
- Numbers of samples taken from each deployment
- Person responsible
- Additional comments.

Digital field data (e.g. water quality data) should be downloaded from the monitoring instrument as soon as practicable following retrieval of the instrument and backed up onto independent storage (e.g. portable hard drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

Summaries of samples collected for all locations visited will be included in standard daily field reports from field teams to TEO.

6.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and backed up to independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual; refer to the overarching OSMP for additional information on data management.

All data sets will be accompanied by a metadata summary; refer to overarching OSMP for additional information on metadata summaries (refer to overarching OSMP (4716-HS-H0114) for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

6.4.3 Data analysis

Samples will be analysed at laboratory with NATA accreditation for the following parameters:

- TRH
- BTEXN
- PAH.

6.5 Quality control

6.5.1 Equipment

All equipment will be checked and calibrated (where required, as per manufacturer's guidelines) prior to mobilisation (Section 5.2.2).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or sample integrity. Independent back up equipment should be mobilised to prevent down time due to equipment failure where practicable.

Decontamination of water sampling equipment will be undertaken prior to sampling at each site. All equipment will be thoroughly cleaned using Decon-90 or suitable alternative (e.g. n-pentane) and rinsed with clean seawater. Compliance with this procedure will be recorded on sample log sheets.

6.5.2 Samples

Following recovery of water samples to deck, the following should be checked:

- Correct sampling site
- Correct sampling equipment (and when last decontaminated) and containers used
- Sufficient volume sampled
- Evidence of leakage
- Depth, position and time recorded when sample taken
- Evidence of contamination (e.g. damaged or ill-fitting bung, anthropogenic material in sample).

Refer to the overarching OSMP for additional information on sample quality control and quality assurance.

6.5.2.1 Blanks

To check the potential contamination of samples, the following blanks should be prepared:

- Field blanks (check for contamination when collecting the sample): blank sample matrix (e.g. acid washed sand) in sealed glassware that is opened and exposed to the sampling environment and the accompanies samples
- Transport/trip blanks: blank sample matrix (e.g. acid washed sand) in sealed glassware that accompanies the empty glassware and samples while remaining sealed at all times
- Rinsate blanks: blank water matrix (e.g. distilled water) that is used to rinse cleaned sampling equipment, collected and analysed
- Spike recovery: typically done by analytical laboratories and reported as part of laboratory quality reporting.

Discuss the requirements for blanks with analytical laboratories, which can provide material and glassware for blanks.

6.5.3 Data management

Data collected during SMP-01 will be stored securely and accurately so that files are not lost and can be easily retrieved by office-based personnel for analysis.

6.5.3.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

Data from the water quality profiler and fluorometer will be downloaded in a standard format and checked to assess the quality of the data (check for unreasonable or inconsistent results) and to identify the depths at which water samples should be taken.

For water quality, checks of sample storage temperatures will be undertaken at the beginning of each shift. For 12-hour operations, this may be undertaken at both the start and the end of each shift.

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the water quality profiler. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation.

Before sending any data to the office, an electronic metadata summary will be completed (and included with the data package) which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to being sealed in the cooler with the samples for transport.

6.5.3.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

6.5.4 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

Upon receiving the analytical results from a laboratory, the results should be reviewed for outliers and an assessment of the quality of the analysis made by a competent scientist. Analytical data should consist of an assessment of duplicate samples, intra- and inter-laboratory duplicates, rinsate samples and blanks. This assessment should be documented in the reporting on the concentrations of hydrocarbons in marine sediments and any discrepancies discussed.

7 Reporting

7.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

7.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, HSE performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs
- Reports detailing the distribution and nature of hydrocarbons attributable to the spill and comparisons of impact sites and reference sites. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated, and the same results obtained by a competent third party unfamiliar with the monitoring program.

Where reference and baseline data are available, data analysis should compare impact sites to references sites while considering baseline data. Where either baseline or reference data are not available, data from impact sites should be compared over time.

Data from other OMPs and SMPs are available that may inform data analysis (e.g. spatial extend of hydrocarbon contamination) should be considered where applicable. Data analysis should also consider the termination criteria for the SMP.

8 References

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological Applications* 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix B.2 SMP02 - Scientific monitoring of hydrocarbons in marine sediments (4716-HS-H0114-12)

SMP-02 - Scientific Monitoring of Hydrocarbons in Marine Sediments

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-12

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-02 - Scientific Monitoring of Hydrocarbons in Marine Sediments for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

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This SMP-02 - Scientific Monitoring of Hydrocarbons in Marine Sediments shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-02 - Scientific Monitoring of Hydrocarbons in Marine Sediments has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
ANZG	Australian and New Zealand Governments and Australian state and territory governments
BACI	Before After Control Impact
CHA	Cliff Head Alpha
CoC	Chain of custody
CRS	Coordinate reference system
EMBA	Environment that may be affected
GDA2020	Geodetic Datum of Australia 2020
GPS	Global Positioning System
ISQG	Interim sediment quality guidelines
JHA	Job hazard analysis
MGA	Map grid of Australia
MSDS	Material Safety Data Sheet
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
PAH	Polycyclic aromatic hydrocarbons
PPE	Personal Protective Equipment
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd
TPH	Total petroleum hydrocarbons
USB	Universal Serial Bus

1 Rationale

The rationale and purpose for this scientific monitoring plan (SMP) is to assess the concentrations of various hydrocarbon fractions in marine sediments, from which inferences about the nature of hydrocarbon contamination can be made. The analysis of the collected data will inform investigations of cause/effect relationships between the hydrocarbon spill and impacts to natural resources.

Note that intertidal and shoreline sediments are not included in this SMP; refer to Scientific monitoring of shoreline and intertidal benthos (SMP-03). SMP-02 is distinct from monitoring for hydrocarbons in marine waters (SMP-01).

1.1 Objectives

The objectives of SMP-02 are to:

- Quantify the nature of hydrocarbons within sediments attributable to the spill over time. This data can subsequently be related to changes in the health and/or condition of key sensitive receptors potentially affected by spilled hydrocarbons, for the purpose of assessing the impact of the spill on natural resources.

2 Decision-making Inputs and Outputs

2.1 Inputs from other plans

In order to inform the initiation and design of SMP-02, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (operational monitoring plan 01 (OMP-01))
- The predicted spill trajectory (OMP-02)
- Concentration of hydrocarbons in water from operational monitoring (OMP-04).

2.2 Outputs to other plans

Given the characteristics of a hydrocarbon spill (i.e. composition) affect how a spill interacts with environmental sensitivities; the outputs from this SMP are of relevance to all other SMPs in understanding hydrocarbon related impacts. The outputs will also be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

Marine sediments throughout the region are considered to be high quality, with few point sources of pollution. Sediment quality data collected by TEO indicates hydrocarbon levels in coastal waters in the vicinity of the Cliff Head operations are very low (typically below the laboratory limit of detection).

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including sediment quality data, are available from the Cliff Head environmental data directory:

TEO Server:

2.5 Initiation criteria

The initiation criteria for implementation of SMP-02 comprise:

- Operational monitoring of hydrocarbons in water and sediment indicate that hydrocarbon levels are above threshold values (OMP-02). These thresholds are based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) recommended toxicant default guideline values for sediment quality and National Assessment Guidelines for Dredging (NAGD) (Department of the Environment, Water, Heritage and the Arts 2009) trigger values for hydrocarbons, as per Table 1.

Table 1 – Toxicant default guideline values for hydrocarbon fractions for sediment quality

Hydrocarbon fraction	Concentration (dry weight)
Naphthalene	160 µg/kg
Low molecular weight polycyclic aromatic hydrocarbons (PAHs)	552 µg/kg
High molecular weight PAHs	1,700 µg/kg
Total PAHs	10,000 µg/kg
Total petroleum hydrocarbons (TPH)	280 mg/kg

2.6 Termination criteria

The termination criteria or this SMP comprise:

- No statistically significant difference in the concentration of hydrocarbons attributable to the spill between sediments sampled at impact and reference sites.

3 Pre-mobilisation Activities

Given the safety risks posed by diving operations, collecting sediment samples via deployment of sediment collection equipment from the vessel (e.g. van Veen grab) is the preferred method for sample collection. This SMP assumes that all sediment samples are collected in this manner; other sampling methods are beyond the scope of this SMP. Should divers be deemed required for sediment sampling, additional equipment, logistics and safety considerations will be required. Note that requirements such as analytical parameters, sample containers, storage and transport etc. would be unchanged.

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching Operational and Scientific Monitoring Plan (OSMP) (4716-HS-H0114), staff required to implement SMP-02 should be suitably qualified and competent to perform the following responsibilities:

- Senior marine scientist(s) – to design the monitoring program and implement the program in the field
- Marine scientist(s) – to implement the SMP under the direction of senior marine scientist(s)
- Vessel staff – to assist in the deployment and recovery of sampling equipment.

All marine scientists deployed to the field work should be competent in conducting marine sediment sampling, including sample handling and storage, sample hygiene and working on vessels.

3.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for SMP-02:

- Chain of Custody (CoC) sheets
- Clean seawater for rinsing
- Cleaning agent (e.g. Decon 90)
- Coolers (including ice bricks) for sample transport
- Digital camera (including spare memory card and battery)
- Glass bowls and plastic spoons or homogenising sediments
- Handheld GPS
- Job Hazard Analysis (JHA)
- Laboratory address labels
- Large heavy duty plastic bags
- Material Safety Data Sheets (MSDS) for all chemicals
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Sample containers (including 10% contingency) with blanks
- Sediment processing equipment (e.g. metal buckets, measuring cylinders)
- Sediment sampler (e.g. van Veen) including spares where practicable
- Suitable lifting equipment (e.g. davit, A frame) rated for intended loads
- Vessel(s) suitable for deployment
- Water quality profiler (e.g. CTD profiler) including dissolved oxygen
- Water samplers (e.g. bomb sampler, Niskin bottle, submersible pump).

3.2.1 Preparation

The following equipment preparation will be undertaken:

- Develop the monitoring design for the SMP in accordance with the principles in the overarching OSMP
- Confirm equipment resources and availability (e.g. number/type of water quality samplers, sampling containers, coolers, ice bricks) to implement the sampling design as per the monitoring program
- Confirm that vessel(s) suitable for deployment of sediment sampling equipment, including load ratings for deployment of sediment samplers
- Confirm work procedures are available and staff are familiar with the operation of any equipment
- Confirm all Global Positioning System (GPS) units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 3.1), including required personal protective equipment (PPE)
- Assemble field consumables, blanks and equipment (refer to Section 3.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm survey sampling plan and continually update as new situational awareness information becomes available
- Co-ordinate National Association of Testing Authorities (NATA)-accredited laboratories to confirm availability, limits of detection, obtain sample analysis quotes and arrange provision of appropriate sample containers, CoC forms, coolers and ice bricks
- Confirm information on sampling holding times and requirements for collection and transport of sediment samples to analytical laboratories
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory.

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring strategy

SMP-02 will monitor hydrocarbon concentrations in marine sediments. Table 2 summarises the monitoring parameters that will be assessed to examine the presence, quantity and character of hydrocarbons in marine waters.

Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 2 – Environmental sensitivities, aspects and methodologies

Environmental sensitivity	Aspect	Methodology
Marine sediments	Hydrocarbon contamination of marine sediment	Hydrocarbon concentrations in marine sediment for laboratory analysis

4.2 Sampling design

SMP-02 will determine the concentrations of hydrocarbons in marine sediments (if present) over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP include:

- Vessel based sediment quality surveys.

The monitoring design strategy should make use of beyond BACI experimental design principles. As such, a series of sites would be expected to be selected based on whether they have been affected by the hydrocarbon spill (i.e. impact sites) or have not been affected by the spill (i.e. reference sites).

Where appropriate baseline data are available, consideration should be given to developing a beyond Before After Control Impact (BACI) monitoring program design (Underwood 1994, 1991), which monitors a range of reference and impact sites over time (i.e. a longitudinal study). Where robust, appropriate baseline data for impact sites are not available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory may be prioritised to obtain baseline data at impact sites prior to hydrocarbon exposure.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP (4716-HS-H0114) for additional details.

4.2.1 Monitoring sites

Monitoring sites will consist of two types of site:

- Impact sites – sites which are known to have been exposed to spilled hydrocarbons
- Reference sites – sites which are known to have not been exposed to spilled hydrocarbons, but are otherwise similar to impact sites.

Note that sites may be further classified on the level of hydrocarbon exposure (i.e. multiple levels within the exposure factor).

Sediment samples should only be collected in areas where bare sediments are available for sampling. Habitats that do not retain sediments (e.g. reefs) or are vegetated (e.g. seagrasses) should not be sampled for marine sediments, as the samples are unlikely to yield sufficient sediments and may snag sampling equipment. The potential impacts to benthic habitats that are not bare sediments are quantified by SMP-03.

Impact and reference sites can be identified from the outputs of OMP-01 and OMP-02, with impact sites drawn from areas known to be, or predicted to be, affected by spilled hydrocarbons. Reference sites can be selected in areas that are beyond the EMBA. In selecting reference sites, consideration of the uncertainty of the EMBA should be born in mind (i.e. TEO should be confident that the reference sites are unaffected by spilled hydrocarbons). The number of each will be determined by the nature of the actual spill event.

Care should be taken when selecting reference sites to ensure that they are comparable to impact sites where practicable. Refer to the overarching OSMP for more detailed discussion on the principles of monitoring program design.

4.2.2 Monitoring parameters

Table 3 outlines the parameters, methodologies and associated parameters that will be used for SMP-02.

Table 3 – Aspects, methodologies and associated parameters for SMP-02

Aspect	Methodology	Parameter
Hydrocarbon concentrations in marine sediments	Sediment samples for hydrocarbons in marine sediments for laboratory analysis	Naphthalene Low molecular weight PAHs High molecular weight PAHs Total PAHs TPH

4.2.3 Monitoring frequency and duration

An initial round of sampling for this SMP should be implemented as soon as practicable following the initiation trigger being reached. The frequency of additional ongoing monitoring will be determined based on an assessment of the results of the OMPs and the preliminary results of this SMP. Monitoring frequency should consider weathering of the spilled hydrocarbon, with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

4.3.1 Sediment quality surveys

Where a surface slick is present, a hydrocarbon-free area will need to be created adjacent to the vessel to mitigate contamination of sampling equipment as it is lowered through the surface of the water. To achieve this, a boom will be deployed from the vessel and surface hydrocarbons will be removed from within via absorbent pads (see Figure 1). While there may still be some trace amounts of hydrocarbons remaining, the majority of floating surface material will be removed via this method, allowing the sampling equipment to be lowered into the water with a reduced risk of contamination.

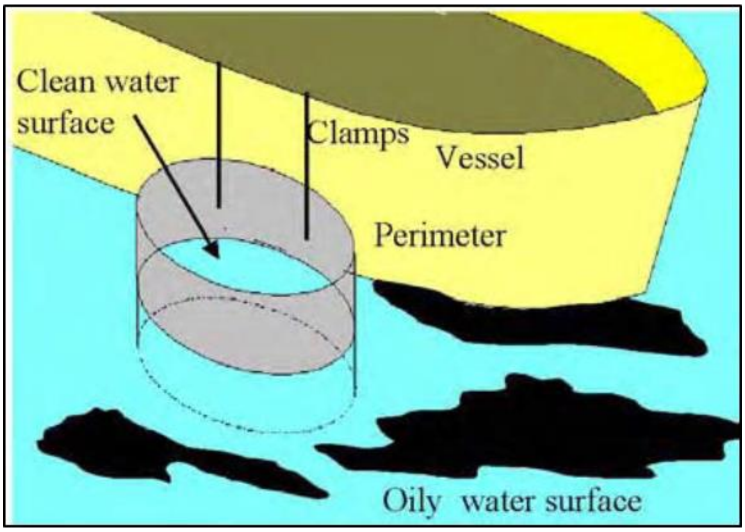

Figure 1 – Example deployment of a bottomless perimeter to create a hydrocarbon-free area for sediment sampling

Once at the sampling site, the following procedure should be followed:

(1) Confirm with vessel master, crew and scientific personnel that sampling is about to commence
(2) Undertake a task briefing to ensure that all personnel understand their roles and responsibilities
(3) Record field observations, including, time, location and meteorological conditions
(4) Prepare the sediment sampler for use (e.g. ensure that it has been decontaminated, sampler prepared as per manufacturer / work instructions)
(5) Lower the sampler to the seabed, confirm the sample has been collected and retrieve the sampler to the deck
(6) Allow excess water to drain from the sampler, taking care to avoid excessive loss of sediments (particularly fines)
(7) If the sediment sample is not completely intact (e.g. due to incomplete closure of the sampler), the sample is discarded and another taken
(8) A photograph of the sediment sample (including details such as site, date, sample number etc. on a white sheet / clapper board) should be taken prior to filling sample vials
(9) The surface sediments (approximately 2-3 cm) are removed and placed in a mixing bowl, homogenised and then sample containers filled with the required quantity of sediment (refer to guidance from analytical laboratories to required mass / volume)
(10) All sample containers should be pre-labelled, or labelled immediately following collection with indelible marker (Section 4.3.2)
(11) Equipment cleaned, decontaminated and prepared for next sample and excess sediment discharged overboard
(12) Samples should be stored in accordance with the holding instructions from the analytical laboratory (typically ~4 °C either refrigerated or in coolers with ice bricks)
(13) Sample details recorded on field data sheet.

Unless sampling in areas where sediments are highly worked (e.g. high energy beaches), hydrocarbon contamination from a spill will be concentrated in the surface sediments. As such, sampling should focus on surface sediments where practicable (approximately 2-3 cm).

Be mindful when filling sample containers to avoid touching the inside of the container or uncapping the containers for any longer than necessary. Pay attention to avoiding potential sources of hydrocarbon contamination such as exhaust fumes, drips from overhead wires or grease covered equipment.

Recommended holding times (Department of the Environment, Water, Heritage and the Arts 2009) for analytical parameters in sediments are summarised in Table 4. It is important to note that this information should be confirmed with laboratories, as holding times and limits of reporting may vary between service providers.

Table 4 – Suggested holding times, sampling containers and storage requirements for marine sediment samples for hydrocarbon analysis

Sample Type	Parameter	Container	Storage	Holding Time
Hydrocarbon Samples	Naphthalene Low molecular weight PAHs High molecular weight PAHs Total PAHs TPH	Solvent rinsed glass jar with Teflon lid	Chill to 4 °C, zero head space, in the dark	2 weeks (if refrigerated)

4.3.2 Sample labelling

All samples should be pre-labelled or labelled immediately following sealing of the container with indelible marker. Sample containers will be clearly labelled with the following information as a minimum:

- Unique sample identification (ensure that the sample identification is clearly recorded in the field data sheet). This sample identification should be unique, concise, unambiguous and clearly linked to the sampling site
- Analytical parameter(s)
- Sample collection time and date
- Project specific job number.

4.3.3 Sample storage and transport

Samples must be handled, stored and transported with care to avoid contamination. Samples should be collected and sent to the specified laboratory for analysis in accordance with holding times wherever practicable. Note that non-compliance with holding times and sample storage requirements may invalidate analytical results.

Samples should be packed securely into suitable size coolers using packing material and ice bricks for delivery to each laboratory. CoC forms should be completed and accompany all analytical samples following collection. Whenever samples change hand (e.g. from field team to courier, from courier to analytical laboratory) the CoC should be updated to reflect this.

4.4 Data management

4.4.1 Field data management

Field observations will be recorded on data sheets during monitoring. Information will be recorded on each data sheet, must include, but is not limited to:

- Date and time of sampling
- Sample site reference code/number
- Water depth(s)
- GPS position
- Sample description
- Numbers of samples
- Metocean conditions
- Person responsible
- Additional comments.

Digital field data (e.g. photographs) should be downloaded as soon as practicable and backed up onto independent storage (e.g. portable hard drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital format should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

Summaries of samples collected for all locations visited will be included in standard daily field reports from field teams to TEO.

4.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual. Refer to the overarching OSMP for additional information on data management (4716-HS-H0114).

All data sets will be accompanied by a metadata summary (refer to overarching OSMP (4716-HS-H0114) for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.4.3 Sample analysis

Samples will be analysed at laboratory with NATA accreditation for the following parameters:

- Naphthalene
- Low molecular weight PAHs
- High molecular weight PAHs
- Total PAHs
- TPH.

4.5 Quality control

4.5.1 Equipment

All equipment will be checked and calibrated (where required, as per manufacturer's guidelines) prior to mobilisation (Section 3.2).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or sample integrity. Independent back up equipment should be mobilised to prevent down time due to equipment failure where practicable.

Decontamination of sediment sampling equipment will be undertaken prior to sampling at each site. All equipment will be thoroughly cleaned using Decon-90 or suitable alternative (e.g. n-pentane) and rinsed with clean seawater. Compliance with this procedure will be recorded on sample log sheets.

4.5.2 Samples

Following recovery of water samples to deck, the following should be checked:

- Correct sampling site
- Correct sampling equipment (and when last decontaminated) and containers used
- Sufficient volume sampled
- Evidence of leakage
- Depth, position and time recorded when sample taken
- Evidence of contamination (e.g. damaged or ill-fitting bung, anthropogenic material in sample).

Refer to the overarching OSMP (4716-HS-H0114) for additional information on sample quality control and quality assurance.

4.5.2.1 Blanks

To check the potential contamination of samples, the following blanks should be prepared:

- field blanks (check for contamination when collecting the sample): blank sample matrix (e.g. acid washed sand) in sealed glassware that is opened and exposed to the sampling environment and the accompanies samples
- transport/trip blanks: blank sample matrix (e.g. acid washed sand) in sealed glassware that accompanies the empty glassware and samples while remaining sealed at all times
- rinsate blanks: blank water matrix (e.g. distilled water) that is used to rinse cleaned sampling equipment, collected and analysed
- spike recovery: typically done by analytical laboratories and reported as part of laboratory quality reporting.

Discuss the requirements for blanks with analytical laboratories, which can provide material and glassware for blanks.

4.5.3 Data management

Data collected during SMP-02 will be stored securely and accurately so that files are not lost and can be easily retrieved by office-based personnel for analysis. The following procedures will be undertaken in the field and office to achieve this.

4.5.3.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

For sediment quality, checks of sample storage temperatures will be undertaken at the beginning of each shift. For 12-hour operations, this may be undertaken at both the start and the end of each shift.

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the camera. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation.

Before sending any data to the office, an electronic metadata summary will be completed (and included with the data package) which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to be sealed in the cooler with the samples for transport.

4.5.3.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

4.5.4 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

Upon receiving the analytical results from a laboratory, the results should be reviewed for outliers and an assessment of the quality of the analysis made by a competent scientist. Analytical data should consist of an assessment of duplicate samples, intra- and inter-laboratory duplicates, rinsate samples and blanks. This assessment should be documented in the reporting on the concentrations of hydrocarbons in marine sediments and any discrepancies discussed.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environmental performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs
- Reports detailing the distribution and nature of hydrocarbons attributable to the spill and comparisons of impact sites and reference sites. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Reports discussing the data collected in relation to SMP-02 should discuss the concentrations of hydrocarbons within sediments in relation to previous monitoring for SMP-02 (if available), as well as potential links between these results and those from other OMPs and SMPs. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

6 References

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Department of the Environment, Water, Heritage and the Arts, 2009. National Assessment Guidelines for Dredging. Department of the Environment, Water, Heritage and the Arts, Canberra.

Appendix B.3 SMP03 - Scientific monitoring of shoreline and intertidal benthos (4716-HS-H0114-13)

SMP-03 - Scientific Monitoring of Shoreline and Intertidal Benthos

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-13

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-03 - Scientific Monitoring of Shoreline and Intertidal Benthos for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

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This SMP-03 - Scientific Monitoring of Shoreline and Intertidal Benthos shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-03 - Scientific Monitoring of Shoreline and Intertidal Benthos has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
4WD	Four Wheel Drive
BACI	Before-After Control-Impact
CHA	Cliff Head Alpha
CoC	Chain of custody
CPCe	Coral Point Count with Extensions
CRS	Coordinate reference system
EMBA	Environment that may be affected
GDA2020	2020
GPS	Global Positioning System
ID	Identification
IMS	Invasive Marine Species
JHA	Job Hazard Analysis
MGA	Map Grid of Australia
MSDS	Material Safety Data Sheet
NATA	National Association of Testing Authorities

Term or abbreviation	Definition
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
PPE	Personal Protective Equipment
SMP	Scientific monitoring plan
SPSS	Statistical Package for the Social Sciences
TEO	Triangle Energy (Operations) Pty Ltd

1 Rationale

The rationale and purpose for scientific monitoring of shoreline and intertidal benthos is to quantitatively assess the environmental impacts and subsequent recovery resulting from a hydrocarbon release and associated response activities.

The scope of this scientific monitoring plan (SMP) encompasses:

- The presence of beached hydrocarbons
- The concentrations of hydrocarbon fractions in sediments
- The effects of hydrocarbons on intertidal biota and subsequent recovery.

Note that scientific monitoring of hydrocarbon effects on subtidal sediments and benthos is outside the scope of this SMP; these matters are specifically addressed within SMP-02 and SMP-04, respectively.

1.1 Objectives

The objectives of this SMP are to:

- Quantify the nature of hydrocarbons within intertidal and shoreline sediments attributable to the spill over time
- Quantify the distribution, abundance and community composition of intertidal marine biota and the ecological impacts that have resulted (if any) from exposure to spilled hydrocarbons
- Determine the subsequent recovery of benthic organisms and communities impacted by spilled hydrocarbons.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of SMP-03, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (operational monitoring plan 01 (OMP-01 – 4716-HS-H0114-01))
- The predicted spill trajectory (OMP-01 – 4716-HS-H0114-01)
- Operational assessment of hydrocarbons in water and sediments (OMP-01 4716-HS-H0114-01).

2.2 Outputs to other plans

The outputs from this SMP are not used to inform the design or implementation of other SMPs or OMPs. The outputs will be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

The shoreline and intertidal environment in the region is relatively exposed to ocean waves and as such generally experienced relatively high wave energy compared to environments such as harbours, estuaries or tidal flats. Shorelines and intertidal benthos are characterised by extensive sandy beaches, with some intertidal platforms in some areas. Island shorelines and intertidal habitat are considered to be of particularly high value because of the typical absence of disturbance to fauna by human activities and predation by introduced and feral animals.

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.5 Initiation criteria

The initiation criteria for implementation of SMP-03 comprise:

- Spilled hydrocarbons have contacted, or are likely to contact, the shoreline of the mainland or offshore islands.

2.6 Termination criteria

The termination criteria or this SMP comprise:

- No statistically significant difference in sediment hydrocarbon concentrations between impact and reference sites
  OR
- Oil pollution effects on benthos are no longer detectable by statistical assessment
  OR
- Evidence of key ecological processes (e.g. recruitment) necessary for post-impact recovery is demonstrated.

3 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching Operational and Scientific Monitoring Plan (OSMP) (4716-HS-H0114), staff required to implement SMP-03 should be suitably qualified and competent to perform the following responsibilities:

- Senior marine scientist(s) – to design the monitoring program and implement the program in the field
- Marine scientist(s) – to implement the SMP under the direction of senior marine scientist(s).

All marine scientists deployed to the field work should be competent in conducting sediment sampling, including sample handling and storage, sample hygiene and working in shoreline and intertidal environments. All marine scientists should be competent in identifying intertidal biota and undertaking photo quadrat sampling.

3.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for SMP-03:

- 4WD Vehicle
- Chain of Custody (CoC) sheets
- Clapper board (or similar) for photo identification
- Cleaning agent (e.g. Decon 90)
- Digital camera (including spare memory card and battery)
- Glass bowls and plastic spoons or homogenising sediments
- Handheld GPS
- Laboratory address labels
- Material Safety Data Sheets (MSDS) for all chemicals
- Quadrats
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Sample containers (including 10% contingency) with blanks
- Sediment processing equipment (e.g. metal buckets, measuring cylinders)
- Transect tapes (up to 50 m)
- Vessel(s) suitable for deployment
- Waders
- Wetsuit boots.

3.2.1 Preparation

The following equipment preparation will be undertaken:

- Develop the monitoring design for the SMP in accordance with the principles in the overarching OSMP
- Confirm equipment resources and availability (e.g. number/type of water quality samplers, sampling containers, coolers, ice bricks) to implement the sampling design as per the monitoring program
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system

- Sampling equipment checked to confirm that it is in good working order and has been calibrated
- Identify access points for sites (e.g. tracks for beach access) and access consent obtained if required (e.g. offshore island nature reserves)
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification that SMP-03 has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase:

- Assemble competent field team (refer to Section 3.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Assemble field consumables, blanks and equipment (refer to Section 3.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Co-ordinate National Association of Testing Authorities (NATA)-accredited laboratories to confirm availability, limits of detection, obtain sample analysis quotes and arrange provision of appropriate sample containers, CoC forms, coolers and ice bricks
- Confirm information on sampling holding times and requirements for collection and transport of water quality samples to analytical laboratories
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory.

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring strategy

SMP-03 will monitor the shoreline and intertidal environment to determine the extent of impacts that may be attributed to a hydrocarbon spill. Table 1 summarises the monitoring parameters that will be used to assess the impact and recovery of shoreline and intertidal benthos following a hydrocarbons spill.

Pre-contact data should also be collected in conjunction where practicable to increase efficiency and make best use of available resources. Any pre-contact data collected as part of early surveillance and survey activities under OMP-03 should be utilised in this scientific monitoring program.

Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 1 – Environmental sensitivities, aspects and methodologies

Environmental sensitivity	Aspect	Methodology
Shoreline and intertidal environments	Intertidal habitats and biota	Photo quadrats of habitat and biota
Shoreline and intertidal sediment quality	Hydrocarbon contamination of intertidal sediments	Sediment samples for hydrocarbons in marine sediments for laboratory analysis

4.2 Sampling design

SMP-01 will confirm the distribution of the spill and variation in the characteristics of the hydrocarbon over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP include:

- Shoreline surveys of mainland (accessible by 4WD) and island (accessible by vessel) coastlines.

Where appropriate baseline data are available, consideration should be given to developing a beyond Before After Control Impact (BACI) monitoring program design (Underwood 1994, 1991), which monitors a range of reference and impact sites over time (i.e. a longitudinal study). Where robust, appropriate baseline data for impact sites are not available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory may be prioritised to obtain baseline data at impact sites prior to hydrocarbon exposure.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP (4716-HS-H0114) for additional details.

4.2.1 Monitoring sites

Monitoring will be conducted at two types of site:

- Impact sites – sites which are known to have been exposed to spilled hydrocarbons
- Reference sites – sites which have not been exposed to spilled hydrocarbons, but are otherwise similar to impact sites.

Note, that sites may be further divided based on the level of hydrocarbon exposure (i.e. multiple levels within the exposure factor).

Impact and reference sites can be identified from the outputs of OMP-1, with impact sites drawn from areas known to be, or predicted to be, affected by spilled hydrocarbons. Reference sites can be selected in areas that are beyond the environment that may be affected (EMBA). In selecting reference sites, consideration of the uncertainty of the EMBA should be born in mind (i.e TEO should be confident that the reference sites will remain unaffected by spilled hydrocarbons). The number of each will be determined by the nature of the actual spill event.

Care should be taken when selecting reference sites to ensure that they are matched to impact sites. Refer to the overarching OSMP (4716-HS-H0114) for more detailed discussion on the principles of monitoring program design.

4.2.2 Monitoring parameters

Table 2 outlines the aspects, methodologies and parameters that will be used for SMP-03.

Table 2 – Aspects, methodologies and associated parameters for SMP-03

Aspect	Methodology	Parameter
Shoreline and intertidal habitat and biota	Photo quadrats	Per cent cover of sessile organisms Shoreline / intertidal habitat classification Species diversity and abundance Presence / absence of hydrocarbons
Hydrocarbon concentrations in shoreline and intertidal sediments	Sediment samples for hydrocarbons in marine sediments for laboratory analysis	Naphthalene Low molecular weight PAHs High molecular weight PAHs Total PAHs TPH

4.2.3 Monitoring frequency and duration

An initial round of sampling for this SMP should be implemented as soon as practicable following the initiation trigger being reached. The frequency of additional ongoing monitoring will be determined based on an assessment of the preliminary results of this SMP. Monitoring frequency should consider weathering of the spilled hydrocarbon; with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

4.3.1 Sediments

Once the sampling sites have been determined, a series of replicate sediment samples should be collected (with the number of replicates determined during the design of the monitoring program). A sample should be collected by:

(1) Randomly placing the sampling quadrat (1 m by 1 m) on the sediment substrate
(2) Collecting a series of five hydrocarbon-free cores (e.g. acrylic), with one core from each corner and the final core from the centre of the quadrat
(3) The surface sediments (approximately 2-3 cm) from each core is homogenised in a hydrocarbon-free container (e.g. glass bowl using plastic spoon) and then sample containers filled with the required quantity of sediment (refer to guidance from analytical laboratories to required mass / volume)
(4) All sample containers should be pre-labelled, or labelled immediately following collection with indelible marker (Section 0)
(5) Equipment cleaned / prepared for next sample (e.g. with Decon 90 and rinsed with clean seawater)
(6) Samples should be stored in accordance with the holding instructions from the analytical laboratory (typically ~4 °C either refrigerated or in coolers with ice bricks)
(7) Sample details recorded on field data sheet.

The homogenised surface sediments from each quadrat constitute a single sample. The number of samples collected (i.e. randomly placed quadrats and associated cores) should be repeated until the desired number of samples has been collected.

Be mindful when filling sample containers to avoid touching the inside of the container or uncapping the containers for any longer than necessary. Pay attention to avoiding potential sources of hydrocarbon contamination such as exhaust fumes, drips from overhead wires or grease covered equipment.

Recommended holding times (Department of the Environment, Water, Heritage and the Arts 2009) for analytical parameters in sediments are summarised in Table 3. It is important to note that this information should be confirmed with laboratories, as holding times and limits of reporting may vary between service providers.

Table 3 –Suggested holding times, sampling containers and storage requirements for shoreline and intertidal sediment samples for hydrocarbon analysis

Sample Type	Parameter	Container	Storage	Holding Time
Hydrocarbon Samples	Naphthalene Low molecular weight PAHs High molecular weight PAHs Total PAHs TPH	Solvent rinsed glass jar with Teflon lid	Chill to 4 °C, zero head space, in the dark	2 weeks (if refrigerated)

4.3.1.1 Sample labelling

All samples should be pre-labelled or labelled immediately following sealing of the container with indelible marker. Sample containers will be clearly labelled with the following information as a minimum:

- Unique sample identification (ensure that the sample identification is clearly recorded in the field data sheet). This sample identification should be unique, concise, unambiguous and clearly linked to the sampling site
- Analytical parameter(s)
- Sample collection time and date
- Project specific job number.

4.3.1.2 Sample storage and transport

Samples must be handled, stored and transported with care to avoid contamination. Samples should be collected and sent to the specified laboratory for analysis in accordance with holding times wherever practicable. Note that non-compliance with holding times and sample storage requirements may invalidate analytical results.

Samples should be packed securely into suitable size coolers using packing material and freezer blocks for delivery to each laboratory. CoC forms should be completed and accompany all analytical samples following collection. Whenever samples change hand (e.g. from field team to courier, from courier to analytical laboratory) the CoC should be updated to reflect this.

4.3.2 Photo quadrats

Once the sampling sites have been determined, a series of replicate photo quadrats should be collected (with the number of replicates determined during the design of the monitoring program) along transects. A sample should be collected by:

(1) Establishing the photo quadrat transect (e.g. linear transect along a marked tape). The transect should be representative. The length of the transect should be determined during the design of the monitoring program. When implementing a stratified sampling program, transects should be contained entirely within the strata used in the design of the monitoring program. Caution should be used to avoid placing transects along environmental gradients (e.g. distance from high water mark); environmental gradients should be constant along transects where practicable.

(2) Collect photo quadrats along the transect at random intervals without replacement (i.e. do not photograph the same substrate twice). Photo quadrats should have some indication of scale within the image frame; typically this is done by placing a fixed quadrat of known size on the substrate within the photograph. The number of photo quadrats to be taken should be determined during the design phase of the experiment and may be refined as additional data area collected. Photo quadrats should be clearly identifiable; for example, record photo quadrat details on clapper board and photograph it.

A point count methodology should be used to assess per cent cover from the photo quadrats. Software (e.g. coral point count with extensions (CPCe) can be used to facilitate point count analysis. A suitable classification scheme for point counts should be developed. Note that classification systems developed for subtidal benthos may not be suitable for shoreline and intertidal photo quadrats. Statistics can then be collated for each transect based on the photo quadrats scored within the transect.

Point counts can be used to identify species diversity, which can include species richness (i.e. the number of species) and species evenness (i.e. the numbers of individual within each species).

4.4 Data management

4.4.1 Field data management

Field observations will be recorded on data sheets during monitoring. Information will be recorded on each of data sheet, including, but not limited to:

- Date and time of sampling
- Sample site reference code/number
- GPS position
- Sample description
- Metocean conditions
- Person responsible
- Additional comments.

Digital field data (e.g. video files, photographs) should be downloaded as soon as practicable and backed up onto independent storage (e.g. portable drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital format should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

Summaries of samples collected for all locations visited will be included in standard daily field reports from field teams to TEO.

4.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and back up on independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.5 Quality control

4.5.1 Samples

Following collection of sediment samples, the following should be checked:

- Correct sampling site
- Correct sampling equipment (and when last decontaminated) and containers used
- Sufficient volume sampled
- GPS position and time recorded when sample taken
- Evidence of contamination (e.g. damaged or ill-fitting bung, anthropogenic material in sample)
- Latex gloves to be worn whilst handling sediment sampling equipment. Gloves should be changed between each sampling location
- Potential anthropogenic contaminants (e.g. sun cream, smoking/smokers, sweat, hydrocarbons from exhaust gases, fuel or cleaning agents) are to be avoided by the personnel in contact with the sediment sampling equipment
- The insides of the sample container lids will not come in contact with anything potentially contaminated (such as hands, gloves, work area or vessel)
- Hands cannot come into contact with the insides or lip of sample bottles or equipment that may contact sediments
- Intra- and inter-laboratory duplicates to provide information on the reliability of laboratory analyses.

4.5.1.1 Blanks

To check the potential contamination of sediment samples, the following blanks should be prepared:

- field blanks (check for contamination when collecting the sample): blank sample matrix (e.g. acid washed sand) in sealed glassware that is opened and exposed to the sampling environment and the accompanies samples
- transport/trip blanks: blank sample matrix (e.g. acid washed sand) in sealed glassware that accompanies the empty glassware and samples while remaining sealed at all times
- rinsate blanks: blank water matrix (e.g. distilled water) that is used to rinse cleaned sampling equipment, collected and analysed.

Discuss the requirements for blanks with analytical laboratories, which can provide material and glassware for blanks.

4.5.2 Data management

4.5.2.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

The storage temperature of sediment samples should be checked at the beginning of each shift. For 12-hour operations, this may be undertaken at both the start and the end of each shift.

All photo quadrats should be checked to ensure they are clearly linked to the sites at which they were taken (e.g. by labels being legible in the photo).

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the water quality profiler. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation.

Before sending any data to the office, an electronic metadata summary will be completed (and included with the data package) which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to being sealed in the cooler with the samples for transport.

4.5.2.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

4.5.3 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

Upon receiving the analytical results from a laboratory, the results should be reviewed for outliers and an assessment of the quality of the analysis made by a competent scientist. Analytical data should consist of an assessment of duplicate samples, intra- and inter-laboratory duplicates, rinsate samples and blanks. This assessment should be documented in the reporting on the concentrations of hydrocarbons in marine sediments and any discrepancies discussed.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environmental performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs.
- Reports detailing the distribution and nature of hydrocarbons attributable to the spill and comparisons of impact sites and reference sites. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Reports discussing the data collected in relation to SMP-03 should discuss the concentrations of hydrocarbons within sediments, along with shoreline and intertidal biota, in relation to previous monitoring for SMP-03 (if available), as well as potential links between these results and those from other OMPs and SMPs. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

6 References

Department of the Environment, Water, Heritage and the Arts, 2009. National Assessment Guidelines for Dredging. Department of the Environment, Water, Heritage and the Arts, Canberra.

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological Applications* 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix B.4 SMP04 - Scientific monitoring of subtidal benthos (4716-HS-H0114-14)

SMP-04 - Scientific Monitoring of Subtidal Benthos

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-14

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-04 - Scientific Monitoring of Subtidal Benthos for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This SMP-04 - Scientific Monitoring of Subtidal Benthos shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-04 - Scientific Monitoring of Subtidal Benthos has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
BACI	Before-After Control-Impact
CATAMI	Collaborative and automated tools for analysis of marine imagery
CHA	Cliff Head Alpha
CoC	Chain of Custody
CPCe	Coral Point Count with extensions
CPCe	Coral Point Count with Extensions
CRS	Coordinate reference system
EMBA	Environment that may be affected
GDA2020	Geodetic Datum of Australia 2020
GIS	Geographic Information System
GPS	Global Positioning System
ID	Identification
IMS	Introduced Marine Species
JHA	Job Hazard Analysis
MGA	Map Grid of Australia
NATA	National Association of Testing Authorities
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
PPE	Personal Protective Equipment
ROV	Remotely operated vehicle
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd

1 Rationale

The rationale and purpose for scientific monitoring of subtidal benthos is to quantitatively assess the environmental impacts and subsequent recovery resulting from a hydrocarbon release and associated response activities.

The scope of this scientific monitoring plan (SMP) encompasses sessile benthic organisms such as:

- Seagrasses
- Macroalgae
- Sponges / filter feeders
- Hard corals
- Soft corals.

Note that intertidal and shoreline habitats are beyond the scope of this SMP; refer to SMP-03 for information on scientific monitoring following a hydrocarbon spill affecting intertidal and shoreline habitats.

1.1 Objectives

The objectives of this SMP are to:

- Quantify the distribution, abundance and community composition of benthic marine organisms and the ecological impacts that have resulted (if any) from exposure to spilled hydrocarbons
- Determine the subsequent recovery of benthic organisms and communities impacted by spilled hydrocarbons.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of this SMP sampling program, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (OMP--01)
- The predicted spill trajectory (OMP-01)
- Evidence of oiling of sediments or benthic habitats (OMP-01).

2.2 Outputs to other plans

The outputs from this SMP are not used as decision making criteria in other SMPs or OMPs. Results from this SMP will be used to report to stakeholders on environmental impacts to subtidal benthos, including TEO internal stakeholders, natural resource management agencies and regulatory authorities. The outputs will also be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

Subtidal benthic habitats in the region include:

- bare sediments
- limestone pavement
- macroalgal reefs
- seagrass meadows.

These benthic habitats provide habitat for a range of species, including important fauna such as the western rock lobster.

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.5 Initiation criteria

The initiation criteria for implementation of this SMP comprise:

- Hydrocarbon spill surveillance or spill trajectory modelling indicate that oil may have contacted, or is likely to contact, benthic habitats (OMP-01 (4716-HS-H0114-01))
  OR
  Evidence of oiling of benthic habitats (OMP01 (4716-HS-H0114-01) or OMP-02 (4716-HS-H0114-02)).

2.6 Termination criteria

The termination criteria or this SMP comprise:

- Oil pollution effects on benthos are no longer detectable by statistical assessment
  OR
- Evidence of key ecological processes (e.g. recruitment) necessary for post-impact recovery is demonstrated.

3 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching operational and scientific monitoring plan (OSMP) (4716-HS-H0114), staff required to implement SMP-04 should hold the following qualifications and competencies:

- Senior marine scientist(s) – to design the monitoring program and implement the program in the field
- Marine scientist(s) – to implement the SMP under the direction of senior marine scientist(s)
- Vessel staff – to assist in the deployment and recovery of sampling equipment.

All marine scientists deployed to the field should have experience in basic taxonomy for temperate marine benthic biota.

Analysis of benthic habitat data beyond that carried out in the field should be undertaken by marine scientists with sufficient taxonomic skill to reliably identify benthic biota to the lowest taxonomic ranking possible (species where possible).

Note that the preferred method of sampling is via towed video, remotely operated vehicle (ROV) or drop camera rather than via divers due to the associated safety risks and costs. This SMP assumes that imagery of the benthos will be acquired using a remote camera system; no allowance has been made for other methods such as divers.

3.2 Equipment

The following equipment may be required:

- Clapper board (or similar) for photo identification
- Handheld GPS
- Job Hazard Analysis (JHA)
- Suitable lifting equipment (e.g. davit, A frame) rated for intended loads
- Underwater imaging system (e.g. drop camera) for photo-quadrats, including batteries, battery chargers and spares as applicable (e.g. o rings, umbilicals, tools)
- Underwater video system (e.g. towed video, ROV) for video transects, including batteries, battery chargers and spares as applicable (e.g. o rings, umbilicals, tools)
- Vessel(s) suitable for deployment
- Suitable office computer equipment for video and still image analysis and storage (including software).

This SMP assumes that all imagery of benthic habitats will be obtained by drop camera, ROV, towed video or similar equipment. Note if diving operations are deemed necessary, additional equipment and safety considerations (e.g. dive planning) will be required, which are beyond the scope of this SMP.

Practical reference material for the identification of temperate marine benthic organisms should be available for use. Examples include (but are not limited to):

- Australian Marine Life: the Plants and Animals of Temperate Waters (Edgar 2012)
- Marine Plants of Australia (Huisman 2019).

3.2.1 Preparation and calibration

The following equipment preparation will be undertaken:

- Develop the monitoring design for the SMP in accordance with the principles in the overarching OSMP
- Confirm equipment resources and availability (e.g. equipment for underwater video transects and photo-quadrats) to implement the sampling design as per the monitoring program
- All wet equipment bench tested prior to deployment to ensure good working order. Water tight seals on submersible equipment (e.g. o rings) should be inspected and maintained in accordance with manufacturer’s instructions prior to use (e.g. coated with silicon grease, free of damage and debris).
- All umbilicals should be inspected for signs of damage or wear prior to deployment.
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order and has been calibrated
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 3.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Assemble field consumables, blanks and equipment (refer to Section 3.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Co-ordinate National Association of Testing Authorities (NATA)-accredited laboratories to confirm availability, limits of detection, obtain sample analysis quotes and arrange provision of appropriate sample containers, CoC forms, coolers and ice bricks
- Confirm information on sampling holding times and requirements for collection and transport of water quality samples to analytical laboratories
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory
- Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring strategy

SMP-04 will monitor the benthic environment to determine the extent of impacts that may be attributed to a hydrocarbon spill. Table 1 summarises the monitoring parameters that will be used to assess the impact and recovery of subtidal benthos following a hydrocarbons spill.

Note that intertidal and shoreline habitats are beyond the scope of this SMP; refer to SMP-03 (4716-HS-H0114-13) for information on conducting scientific monitoring in these environments.

Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 1 – Environmental sensitivities, aspects and methodologies

Environmental sensitivity	Aspect	Methodology
Seagrasses Macroalgae Bare sediment Benthic invertebrates (e.g. hard corals, soft corals, sponges etc.)	Benthic habitats and biota	ROV Towed video Drop camera

4.2 Sampling design

SMP-01 will confirm the distribution of the spill and variation in the characteristics of the hydrocarbon over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP include:

- Vessel based video transect surveys
- Vessel based benthic photo-quadrats.

The monitoring design strategy should make use of beyond BACI experimental design principles (Underwood 1994, 1991). As such, a series of sites would be expected to be selected based on whether they have been affected by the hydrocarbon spill (i.e. impact sites) or have not been affected by the spill (i.e. reference sites).

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP (4716-HS-H0114) for additional details.

4.2.1 Monitoring sites

Monitoring will be conducted at two types of site:

- Impact sites – sites which are known to have been exposed to spilled hydrocarbons
- Reference sites – sites which have not been exposed to spilled hydrocarbons, but are otherwise similar to impact sites.

Note, that sites may be further divided based on the level of hydrocarbon exposure (i.e. multiple levels within the exposure factor).

Impact and reference sites can be identified from the outputs of OMP-01 and OMP-02, with impact sites drawn from areas known to be, or predicted to be, affected by spilled hydrocarbons. Reference sites can be selected in areas that are beyond the EMBA. In selecting reference sites, consideration of the uncertainty of the EMBA should be born in mind (i.e. TEO should be confident that the reference sites will remain unaffected by spilled hydrocarbons if there is a sudden change in the weather conditions or ocean currents). The number of each will be determined by the nature of the actual spill event.

Care should be taken when selecting reference sites to ensure that they are matched to impact sites. Refer to the overarching OSMP for more detailed discussion on the principles of monitoring program design.

4.2.2 Monitoring parameters

Table 2 outlines the parameters, methodologies and associated metrics that will be used for SMP04.

Table 2 – Aspects, methodologies and associated parameters for SMP-04

Aspect	Methodology	Parameter
Benthic habitats and biota	Video transects Still imagery	Per cent cover of benthic organisms Benthic habitat classification Benthic species diversity and abundance Presence / absence of hydrocarbons

4.2.3 Monitoring frequency and duration

An initial survey for this SMP should be implemented as soon as practicable following the initiation trigger being reached. The frequency of additional ongoing monitoring will be determined based on an assessment of the results of the OMPs and the preliminary results of this SMP.

Monitoring frequency should consider weathering of the spilled hydrocarbon, with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

Imagery of the seabed can be collected by a range of methods including towed video, drop camera or ROV. Imagery can be classified into two groups:

- Video imagery – a continuous stream of footage of the benthos collected by towed video or ROV. Note that still images can be extracted from the video footage, but may be of poor image quality (e.g. resolution, focus etc.). Video imagery is typically collected along transects
- Still imagery – discrete still images of the seabed, typically collected by drop camera or ROV, although may be extracted from video footage. Still imagery is typically collected at points.

Note that the collection of video and still imagery are not mutually exclusive, both can be collected.

Samples should be collected within sites, with the number of replicate samples collected within each site being equal where practicable. The number of replicate samples within sites should be informed where possible using *a priori* power analysis, with sufficient replicates to ensure that any statistical analyses of monitoring results is of an acceptable power to detect an effect (refer to OSMP (4716-HS-H0114) for a discussion of power).

Sampling in the shallow subtidal environment near beaches with breaking waves is operationally challenging, however these benthic environments are typically characterised by bare, unconsolidated sediments. As such, they are unlikely to host significant sessile benthic assemblages.

The following information should be recorded as a minimum in relation to each video transect or still image:

- Site identification (ID)
- Transect ID
- Name of digital file
- Imaging equipment model and serial number
- Date and time
- Scientist(s) responsible
- Start and end GPS positions
- Estimated transect depth
- Benthic classifications
- Comments.

4.3.1 Video imagery

Where video footage of the seabed is the preferred sampling method, footage should be collected along randomly selected transects of the same length. The length of the transect should be such that it remains within the site (e.g. within a particular habitat) and, if the monitoring design is stratified or blocked, with the boundaries of the parameter used for the stratification.

The video footage should be classified using a habitat or biota classification system. A number of classification schemes are available, including the publicly available collaborative and automated tools for analysis of marine imagery (CATAMI) classification scheme (www.catami.org).

A competent marine scientist should make classifications of the benthos while reviewing the live video imagery from the seabed in conjunction with the position of the camera. This can be carried out in a range of GIS applications. The video footage should also be recorded (including spatial information as an overlay) to allow review after the transect has been completed.

The classification system should include suitable classifications based on sessile benthic organisms known to occur within the environment that may be affected, and also include physical substrate categories.

4.3.2 Still imagery

Still imagery of the seabed can be collected using a drop camera, ROV, or by extracting frames from video footage of the seabed.

Note that still images extracted from video footage (e.g. towed video, ROV) may produce a view of the benthos at an oblique angle rather that perpendicular to the seabed. This can introduce potential bias when using such images to estimate parameters such as per cent cover. Drop camera sampling (and ROV sampling) for still images reduce this source of bias by collecting images that are perpendicular to the seabed.

A point count methodology should be used to assess per cent cover from images of the benthos (preferably derived from a drop camera or downward facing towed video camera or ROV). Software (e.g. coral point count with extensions (CPCe)) can be used to facilitate point count analysis. A suitable classification scheme for point counts should be developed. Note that there are publicly available classification schemes available that may be suitable, such as the CATAMI classification system.

Point counts can be used to identify species diversity, which can include species richness (i.e. the number of species) and species evenness (i.e. the numbers of individual within each species).

4.4 Data management

4.4.1 Field data management

Field observations will be recorded on data sheets during monitoring. Information will be recorded on each of data sheet, including, but not limited to:

- Date and time of sampling
- Sample site reference code/number
- Imaging equipment model and serial number
- Water depth(s)
- GPS position
- Sample description
- Metocean conditions
- Person responsible
- Additional comments.

Digital field data (e.g. video files, photographs) should be downloaded as soon as practicable and backed up onto independent storage (e.g. portable hard drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital format should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

Summaries of data collected from all locations visited will be included in standard daily field reports sent from field teams to TEO.

4.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and backed up to independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.5 Quality control

4.5.1 Equipment

All equipment will be checked and calibrated (where required, as per manufacturer's guidelines) prior to mobilisation (Section 3.2).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or data integrity.

Independent back up equipment should be mobilised to prevent down time due to equipment failure where practicable.

If submersible equipment is not going to be used within one hour of recovery, it should be rinsed with fresh water.

All submersible equipment should be rinsed thoroughly with fresh water following completion of sampling.

4.5.2 Data management

Data collected during SMP-04 will be stored securely and accurately inventories so that files are not lost and can be easily retrieved by office-based personnel for analysis.

Following demobilisation from the field, all data should be backed up and archived with an accompanying metadata summary (refer to overarching OSMP (4716-HS-H0114) for additional information on metadata summaries). Suggested back up include redundant network drive storage, tape drive backups, optical media or hard drives.

A metadata summary should be developed for all data sets collected in accordance with the guidance in the overarching OSMP. The metadata should be sufficient to facilitate archiving, querying and retrieval of data sets.

4.5.3 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

A quality control program should be implemented for all data analysis. Where scientific personnel are undertaking habitat classifications, identification of benthic organisms, per cent cover estimates / analysis, or other assessments that may be subjective, there should be routine checks by suitably competent independent marine scientist / taxonomist. Feedback should be shared with all staff undertaking such assessments to facilitate ongoing consistency.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environmental performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs
- Reports detailing the distribution and nature of hydrocarbons attributable to the spill and comparisons of impact sites and reference sites. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Reports discussing the data collected in relation to SMP-04 should discuss the concentrations of hydrocarbons within sediments in relation to previous monitoring for SMP-04 (if available), as well as potential links between these results and those from other OMPs and SMPs. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

6 References

Edgar, G.J., 2012. *Australian marine life: the plants and animals of temperate waters.* Second Edition. New Holland Publishers, Sydney.

Huisman, J.M., 2019. *Marine plants of Australia.* Revised Edition. University of Western Australia Publishing, Nedlands.

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix B.5 SMP05 - Scientific monitoring of seabirds and shorebirds (4716-HS-H0114-15)

SMP-05 - Scientific Monitoring of Seabirds and Shorebirds

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-15

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-05 - Scientific Monitoring of Seabirds and Shorebirds for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This SMP-05 - Scientific Monitoring of Seabirds and Shorebirds shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-05 - Scientific Monitoring of Seabirds and Shorebirds has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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3	Anthony See, Asset & Integrity Manager (TEO)
4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP--04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
BACI	Before-After Control-Impact
CHA	Cliff Head Alpha
COC	Chain of custody
CRS	Reference System
DBCA	Department of Biodiversity, Conservation and Attractions
EMBA	Environment that may be affected
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GDA2020	Geodetic Datum of Australia 2020
GPS	Global positioning system
ID	Identification
IMS	Invasive Marine Species
JHA	Job hazard analysis
MGA	Map Grid of Australia
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd
UAV	Unmanned aerial vehicle

1 Rationale

The rationale and purpose for the scientific monitoring plan 05 (SMP-05 (4716-HS-H0114-15)) is to assess the impacts and subsequent recovery of seabird and shorebird populations in response to a hydrocarbon spill event and spill response activities.

Seabirds and shorebirds will be assessed as they may be affected by spilled hydrocarbons, including direct impacts of the spill (e.g. oiling), ingestion of contaminated food, and loss of food sources and habitat due to spill impacts and/or spill response activities (e.g. shoreline clean-up). Impacts may include illness/injury, reduced reproductive success and mortality.

Scientific monitoring will focus on seabird populations when roosting and nesting on land and shorebird populations when feeding, breeding and nesting.

1.1 Objectives

The objectives of SMP-05 are to:

- Collate and quantify impacts to seabirds and shorebirds from results recorded during operational monitoring plan 04 (OMP04 (4716-HS-H0114-04)) (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population level
- Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to seabirds and shorebird populations at breeding colonies or roosts that may have been impacted by spilled hydrocarbons.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of SMP-05, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP-01 (4716-HS-H0114-01))
- The predicted spill trajectory (OMP-01 (4716-HS-H0114-01))
- Evidence of contact with seabird or shorebirds during operational response (OMP-04 (4716-HS-H0114-04))
- Information on the nature of the spilled hydrocarbon over time (SMP-01 - (4716-HS-H0114-11))
- Areas known to or expected to host seabird and shorebird aggregations.

2.2 Outputs to other plans

The data and analysis associated with SMP-05 is not used to inform decision making in relation to other SMPs or OMPs. The outputs will be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

The region surrounding the Cliff Head development hosts a range of seabirds and migratory shorebirds. In particular, the offshore islands in the region, such as the Houtman Abrolhos islands and Beagle Island, may host birds listed as migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Species listed as migratory under the EPBC Act are considered to be matters of national environmental significance. Note that there are no Ramsar listed wetlands in the vicinity of the Cliff Head development. Seabird species that forage at sea, such as shearwaters and gannets, are at particular risk of oiling from surface slicks.

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.5 Initiation criteria

The initiation criteria for SMP-05 comprise:

- Operational monitoring indicates that contact with seabirds or shorebirds has occurred or is likely, or spilled hydrocarbons overlap known bird habitat.

2.6 Termination criteria

The termination criteria for this SMP comprise:

- The level of impact to affected seabird and shorebird populations has been quantified
  OR
- The impacts to important habitat (feeding, breeding and roosting areas) are not significantly different to reference areas or baseline
  OR
- The impacts of the hydrocarbon spill are no longer statistically detectable.

3 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching operational and scientific monitoring plan (OSMP) (4716-HS-H0114), staff required to implement SMP-05 should hold the following qualifications and competencies:

- Senior marine scientist(s) – to design the monitoring program design and implement the program in the field
- Marine scientist(s) – to implement SMP under the direction of senior marine scientist.

All personnel conducting observations and sampling of seabirds and shorebirds will have suitable training on species identification and survey procedures/techniques.

Access to colonies or nesting sites may require vessels, aircraft or vehicles and therefore, additional team members and qualifications required.

3.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for SMP-05:

- Vehicles for accessing survey areas may include vessels, aircraft and off-road automobiles or unmanned aerial vehicles (UAV), as required
- Binoculars
- Chain of Custody (CoC) sheets
- Clapper board (or similar) for photo identification
- Communications (e.g. mobile or satellite telephone, radios)
- Coolers (including ice bricks) for sample transport
- Digital camera(s) (including spare memory card and battery)
- Handheld GPS
- Job Hazard Analysis (JHA)
- Laboratory address labels
- Large heavy duty plastic bags
- Latex gloves
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Suitable office computer equipment for video and still image analysis and storage (including software)
- Tape measures
- Transect tapes (up to 50 m)
- Video camera(s) (including spare memory cards and batteries).

3.2.1 Preparation

The following activities will need to be undertaken, to ensure equipment is in working order, prior to mobilisation to the field:

- Develop sampling program consistent with principles in OSMP, this SMP and available existing data
- Liaise with wildlife management agencies (e.g. Department of Biodiversity, Conservation and Attractions (DBCA) Parks and Wildlife Service) to determine permitting requirements for carcass collection and access to offshore island nature reserves. provides licensing exemption for caring/protecting native fauna. DBCA Parks and Wildlife Service’s Wildcare Helpline has means to contact Licensing Officers afterhours

- Confirm equipment resources and availability to implement the sampling design as per the monitoring program
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order and has been calibrated
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 3.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Assemble field consumables, blanks and equipment (refer to Section 3.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring strategy

SMP-05 will monitor seabird and shorebirds in areas at risk from hydrocarbon spill exposure and spill response activities as well as in reference areas not exposed to spilled hydrocarbons. Table 1 summarises the monitoring parameters that will be used to assess the impact and recovery of seabirds and shorebirds in the case of a spill incident.

Pre-impact data should be collected in conjunction with other OMPs and SMPs to increase efficiency and make best use of available resources. Any pre-contact data collected as part of early surveillance and survey activities should be utilised in this scientific monitoring program. Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 1 – Environmental sensitivities, aspects and methodologies for SMP-05

Environmental sensitivity	Aspect	Methodology
Seabirds and shorebirds • Offshore islands • Mainland	Surveys of roosting / nesting areas recording: • Counts of bird species • Counts of nest (including chicks) • Injury/oiling/mortality	Point, transect or areal visual surveys (direct and/or video / photographic), recording: • Counts of birds by species, noting life-stage (age), health/condition and behaviour, including any injury, oiling or mortality • Nesting activity / breeding effort • Opportunistic observations during implementation of OMPs / SMPs

4.2 Sampling design

SMP-05 will investigate the effects of hydrocarbon spills and spill response activities on seabirds and shorebirds. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP include:

- Surveys of roosting / nesting areas (onshore and / or offshore)
- Opportunistic observations during implementation of OMPs and SMPs

Where feasible, the survey design for the assessment of spill impacts and recovery will follow a Before-After-Control-Impact (BACI) approach with multiple reference sites, also known as ‘beyond-BACI’ (Underwood 1994, 1991). However, given the relatively small numbers of suitable roosting / nesting habitats within the environment that may be affected (EMBA) identified for credible spill scenarios, it may not be possible to implement a beyond BACI monitoring program, as small amount of roosting / nesting habitats would constraint the number of sites that could be compared.

In the event that a BACI monitoring program cannot be successfully implemented, a repeated measures design applied to the same site can be used to monitor change over time (particularly if baseline data are available). While the inferences that can be drawn from a repeated measures design are weaker than those of a beyond BACI design, such inferences can still be informative regarding the nature and scale of hydrocarbon spill impacts to birds.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

4.2.1 Monitoring sites

The number and types of sites monitored will depend on the design of the monitoring program which is dependent on the size, location and time of year of the spill event, and the potential number of colonies and nesting sites affected. Information from OMP-01 (4716-HS-H0114-01) and OMP-04 (4716-HS-H0114-04) will be used to understand the spill trajectory and the potential exposure of colonies and nesting sites to spilled hydrocarbons. This data will allow the identification of impact sites (all colonies/nesting sites that may have been exposed to hydrocarbons) and reference sites (where applicable).

4.2.2 Monitoring parameters

Table 2 outlines the parameters, methodologies and associated parameters that will be used for SMP-05.

Table 2 – Aspects, methodologies and associated parameters for SMP-05

Aspect	Methodology	Parameter
Surveys of roosting / nesting areas recording: • Counts of bird species • Counts of nest (including chicks)	Point, transect or areal visual surveys (direct and/or video / photographic)	Counts of birds by species, noting life-stage (age), health/condition and behaviour, including any injury, oiling or mortality Nesting activity / breeding effort
Injury/oiling/mortality	Point, transect or areal visual surveys (direct and/or video / photographic) Opportunistic observations during implementation of OMPs / SMPs	Counts of birds by species, noting life-stage (age), health/condition and behaviour, including any injury, oiling or mortality

4.2.3 Monitoring frequency and duration

The frequency of monitoring will be determined based on the results of the first round of sampling undertaken in this SMP. Many seabirds and migratory shorebirds breed or are present seasonally. This seasonality should be considered when determining the timing of additional monitoring.

Monitoring frequency should consider weathering of the spilled hydrocarbon, with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

4.3.1 Surveys of seabird and shorebirds

Surveys of seabirds and shorebirds consist of counts of individuals via visual observations. Counts of birds should identify birds to the lowest taxonomic resolution possible. Counts should also be made of breeding pairs / hatchlings / nesting sites where the surveys include breeding colonies. Note that counts of hatchlings / nesting sites typically require ground personnel to survey the colony on foot.

Surveys of seabirds and shorebirds can be undertaken from a range of platforms:

- Vessel-based surveys: observers are stationed onboard a vessel
- Airborne surveys: observers are situated onboard an aerial platform such as a helicopter or fixed wing aircraft
- Ground-based surveys: observers are ground based, typically on foot. Note that accessing locations for ground-based surveys may require vehicles or vessels to access the survey area. Note that much of the coastline within the EMBA is accessible by suitable 4-wheel drive vehicles
- Use of UAVs may improve count accuracy and reduce on the ground field work time.

Each survey method has particular considerations which are discussed below. Note that the most practicable (e.g. cost benefit, safety and logistic considerations) survey method(s) should be used; not all survey methods are required to be implemented. All survey methods should be mindful of recounts (i.e. counting an individual bird more than once).

Vessel and ground-based surveys may provide opportunities to collect bird carcasses for examination. Where carcasses are found, the carcass should be photographed in situ, recovered, sealed in a plastic bag and stored in refrigerated storage (e.g. cooler with ice blocks). Carcasses must be labelled with the following minimum information:

- Date and time
- GPS position
- Sample identification (ID) number, if sample taken
- Image ID number, if images taken
- Person responsible
- Additional comments.

Carcasses should be provided to environmental management agencies in accordance with collection licence requirements, or their delegate (e.g. veterinarian) as soon as practicable. Recovered carcasses should be inspected by suitably competent personnel (e.g. veterinarian) for signs of hydrocarbon exposure (e.g. oiled feathers) and to determine the cause of death. The inspection of carcasses may include assessment of biopsy samples for evidence of hydrocarbon exposure.

Interactions with seabirds and shorebirds during surveys may lead to impacts to these fauna. Care should be taken to avoid impacts to birds while achieving the survey objectives. Liaison with wildlife management agencies (e.g. DBCA’s Parks and Wildlife Services) should be carried out prior to undertaking sampling and any permit / licence requirements. Subject matter experts should also be consulted for advice on development and implementation of a sampling program.

4.3.1.1 Vessel-based surveys

Vessel-based surveys will provide detailed and robust data on the at-sea distribution of seabirds. Vessel surveys should sample along pre-determined strip transects as observers utilise optical equipment (spotting scope or binoculars) to record seabird observations. Observers will record abundance, bird behaviours and observations of impacts from hydrocarbons (e.g. oiling, injury, mortality). Transect details (start/end points) should be captured at each survey location using a GPS. Where possible, photographs will be taken to assist in the species identification and counts. General meteorological observations will also be made at the time of survey, including temperature, precipitation, wind direction and strength and visibility.

Vessel-based surveys can also be used to survey the shoreline for seabirds and shorebirds where access via land is restricted and offshore. Observers on the vessel will collect observations on seabirds and shorebirds using high resolution binoculars and will collect positional (GPS) data for sightings and record data on data sheets. Each transect will be completed twice, with observations made each time. Data will include qualitative assessments of seabird and shorebird abundance, spatial distribution, nesting activity, and any indications of direct hydrocarbon exposure.

Note that vessel-based observations of birds should be made opportunistically during implementation of other OMPs and SMPs.

4.3.1.2 Airborne surveys

Airborne surveys can be carried out from helicopters, fixed wing aircraft or UAVs. Airborne surveys should target known aggregation areas such as roosting or nesting sites. Airborne surveys should fly transects over such sites, with competent observers on-board counting the numbers of birds (or collecting imagery in the case of UAVs). Counts should be independently carried out by more than one observer while sampling along transects to facilitate comparisons between observers (e.g. two observers on one side of a fixed wing aircraft) where practicable. In addition to counts from observers, video or photographic images should also be recorded to allow additional counts to be made after completion of the flight.

While flying at lower altitude may facilitate counts of birds, the increased risk of bird strikes and the noise disturbance to roosting / nesting birds should be considered prior to undertaking airborne surveys. Airborne sampling also requires additional safety consideration.

4.3.1.3 Ground-based surveys

Shoreline surveys will determine the abundance, species composition, and nesting behaviour of seabirds and shorebirds at monitoring sites.

Each monitoring site should be split into sections and field personnel should work in teams to survey each section by following pre-determined transects to ensure full coverage of the site. Teams will record abundance, sex (where possible), presence of nests, indications of active or non-active nesting, including signs of nest use (e.g. bird standing by nest, bird sitting on nest, presence of eggs, chicks visible, faeces in nest), and quantify bird abundance and nesting birds/chicks. Geographical information on the extent of the colony, survey points within the colony and transect details (start/end points) should be captured at each survey location using a GPS. Photographs can be taken to assist in the species identification and counts. General meteorological observations will also be made at the time of survey, including temperature, precipitation, wind direction and strength and visibility. Surveys can be repeated over several days to understand temporal variability in use of colonies/nesting and roosting sites by seabirds and shorebirds.

4.4 Data management

4.4.1 Field data management

Field data will be recorded on data sheets during monitoring. Information will be recorded on each data sheet, including, but not limited to:

- Date and time of sampling
- Site reference, sample/survey type and code/number
- AV equipment model, type, ID#; memory card ID#
- Digital filenames (or name-number range)
- GPS position
- Species
- Abundance
- Life-stage (age)
- Behaviour
- Health/Condition
- Hydrocarbon Exposure
- Breeding/Nesting Activity
- Person responsible
- Additional comments.

Digital field data (e.g. video and photographs) should be downloaded as soon as practicable following retrieval of the instrument and backed up onto independent storage (e.g. portable hard drives). Photographs should be named and stored using a system that clearly links images to sites and facilitates storage, retrieval and back up. Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

4.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and backed up to independent digital storage. Data should be managed and stored in accordance with ROC's Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.5 Quality control

4.5.1 Equipment

All equipment will be checked prior to mobilisation (Section 3.2.1).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or sample integrity.

4.5.2 Samples

Recovered carcasses should be checked to ensure they are correctly labelled and provided to environmental management agency (e.g. wildlife officer) or their delegate. All samples should be accompanied by a CoC form.

4.5.3 Data management

4.5.3.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the memory cards. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation. An electronic metadata summary will be completed which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to being sealed in the cooler with the samples for transport.

Taxonomic assessments should be routinely cross checked to ensure that species are identified accurately.

4.5.3.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

4.5.4 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs
- Reports detailing the impacts (if any) on seabirds and shorebirds as a result of a hydrocarbon spill. Reports should contain descriptive statistics of data collected. Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Where reference and baseline data are available, data analysis should compare impact sites to references sites while considering baseline data. Where either baseline or reference data are not available, data from impact sites should be compared over time. Data analysis should consider measures of species abundance and diversity (i.e. counts of species), breeding pairs (where nesting occurs) and breeding success (numbers of chicks, survival of chicks).

Data from other OMPs and SMPs are available that may inform data analysis (e.g. spatial extend of hydrocarbon contamination) should be considered where applicable. Data analysis should also consider the termination criteria for the SMP.

6 References

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological Applications* 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix B.6 SMP06 - Scientific monitoring of sea lions, cetaceans and turtles (4716-HS-H0114-16)

SMP-06 - Scientific Monitoring of Sea Lions, Cetaceans and Turtles

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-16

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-06 - Scientific Monitoring of Sea Lions, Cetaceans and Turtles for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This SMP-06 - Scientific Monitoring of Sea Lions, Cetaceans and Turtles shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-06 - Scientific Monitoring of Sea Lions, Cetaceans and Turtles has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SM-P01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
4WD	Four Wheel Drive
BACI	Before-After Control-Impact
BC Act	*Biodiversity Conservation Act* 2016
CHA	Cliff Head Alpha
CoC	Chain of custody
CRS	Coordinate Reference System
DBCA	Department of Biodiversity, Conservation and Attractions
EMBA	Environment that may be affected
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GDA2020	Geodetic Datum of Australia 2020
GPS	Global positioning system
ID	Identification
IMS	Invasive Marine Species
JHA	Job hazard analysis
MFOs	Marine Fauna Observers
MGA	Map Grid of Australia
MMOs	Marine Mammal Observers
MNES	Matters of national environmental significance
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
PPE	Personal Protective Equipment
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd

1 Rationale

The purpose of scientific monitoring plan 06 (SMP-06) is to assess impacts which may have resulted from the hydrocarbon spill to large marine fauna (referred to in this plan as significant fauna), including:

- Sea lions
- Cetaceans
- Marine turtles.

Significant fauna are at risk of exposure to hydrocarbons if they are present within the environment that may be affected (EMBA) of a hydrocarbon spill. All are air breathing vertebrates that may be exposed to hydrocarbon slicks when surfacing to breathe. Significant fauna are also of conservation significance and generally occupy relatively high trophic levels of food webs. Significant fauna may include species listed as maters of national environmental significance (MNES) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the schedules of the Western Australian *Biodiversity Conservation Act 2016* (BC Act). Consideration of MNES or scheduled fauna should be made when developing a monitoring program for SMP-06.

The nature of hydrocarbon related impacts will depend on the level of oiling and susceptibility of individual species. External exposure can result in dermal injury, eye injury, and if in the vicinity of the immediate hydrocarbon release, inhalation of volatile hydrocarbons can result in sub-lethal or lethal impacts.

1.1 Objectives

The objectives of SMP-06 are to:

- Observe and quantify the presence of significant fauna within the area affected by a hydrocarbon spill
- Assess and quantify lethal or sub-lethal impacts (e.g. behaviour and/or condition changes) of this exposure or interactions
- Evaluate/confirm if hydrocarbons or spill response activities were the cause of observed impacts
- Evaluate recovery of key biological activities (i.e. foraging activity, breeding) for significant fauna following impacts due to a hydrocarbon spill and clean-up procedures.

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of SMP-06, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP-01 (4716-HS-H0114-01))
- The predicted spill trajectory (OMP-01 (4716-HS-H0114-01))
- Evidence of contact with significant fauna during operational response (OMP-04 (4716-HS-H0114-04))
- Areas known to or expected to host significant fauna.

2.2 Outputs to other plans

The data and analysis associated with SMP-06 is not used to inform decision making in relation to other SMPs or OMPs. The outputs will be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

Significant fauna may include species listed as maters of national environmental significance (MNES) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the schedules of the Western Australian *Biodiversity Conservation Act 2016* (BC Act). Consideration of MNES or scheduled fauna should be made when developing a monitoring program for SMP-06. Significant fauna may include:

- Sea lions – including colonies at the Abrolhos Islands and Beagle Island)
- Cetaceans – including local (e.g. coastal dolphins) and seasonally present (e.g. humpback whales) populations
- Marine turtles – no known nesting areas, expected to be very low numbers transiting the area)
- White sharks (particularly around sea lion colonies).

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.5 Initiation criteria

The initiation criteria for SMP-06 comprise:

- Spilled hydrocarbons overlapping known significant fauna habitats
- Evidence of oiling of significant fauna.

2.6 Termination criteria

The termination criteria or this SMP comprise:

- The level of impact to affected significant fauna populations has been quantified
  OR
- The impacts to important habitat (feeding, breeding and migration areas) are not significantly different to reference areas
  OR
- The impacts of the hydrocarbon spill are no longer statistically detectable.

3 Pre-mobilisation activities

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching operational and scientific monitoring plan (OSMP) (4716-HS-H0114), staff required to implement SMP-06 should be suitably qualified and competent to perform the following responsibilities:

- Senior marine scientist – to design the monitoring program design and implement the program in the field
- Marine scientist(s) – to implement SMP under the direction of senior marine scientist
- Environmental management agency staff (or their delegate e.g. veterinarian) or carcass inspection (if required).

All personnel conducting observations and sampling of significant fauna will be competent in species identification and survey procedures/techniques. In particular, experienced marine fauna observers (MFOs) / marine mammal observers (MMOs) should be utilised where possible.

Access to colonies or nesting sites may require vessels, aircraft or vehicles and therefore, additional team members and qualifications required.

3.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for SMP-06:

- Vehicles for accessing survey areas may include vessels and off-road vehicles as required
- Binoculars
- Chain of Custody (CoC) sheets
- Clapper board (or similar) for photo identification
- Communications (e.g. mobile or satellite telephone, radios)
- Digital camera(s) (including spare memory card and battery)
- Handheld GPS
- Job Hazard Analysis (JHA)
- Large heavy duty plastic bags
- Latex gloves
- Suitable office computer equipment for video and still image analysis and storage (including software)
- Vessel(s) suitable for deployment
- Video camera(s) (including spare memory cards and batteries).

3.2.1 Preparation

The following activities will need to be undertaken, to ensure equipment is in working order, prior to mobilisation to the field:

- Develop sampling program consistent with principles in OSMP, this SMP and available existing data
- Liaise with wildlife management agencies (e.g. Department of Biodiversity, Conservation and Attractions (DBCA)) to determine permitting requirements for carcass collection and access to offshore island nature reserves. The Biodiversity Conservation regulations 2018 provides licensing exemption for caring/protecting native fauna. DBCA Wildcare Helpline has means to contact Licensing Officers afterhours
- Confirm equipment resources and availability to implement the sampling design as per the monitoring program

- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order and has been calibrated
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification this SMP has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase for all field teams:

- Assemble competent field team (refer to Section 3.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Assemble field consumables and equipment (refer to Section 3.2)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers.
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Develop and implement JHA and TEO health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring strategy

SMP-06 will monitor significant fauna in areas at risk from hydrocarbon spill exposure and spill response activities as well as in non-oiled reference areas. Table 1 summarises the monitoring parameters that will be used to assess the impact and recovery of significant fauna in the case of a spill incident.

Pre-impact data should be collected in conjunction with other OMPs and SMPs to increase efficiency and make best use of available resources. Any pre-contact data collected as part of early surveillance and survey activities should be utilised in this scientific monitoring program. Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 1 – Environmental sensitivities, aspects and methodologies for SMP-06

Environmental sensitivity	Aspect	Methodology
Significant fauna	Evidence of direct impacts of hydrocarbons (e.g. oiling) Changes in populations	Airborne surveys Vessel-based surveys Ground surveys Necropsy/tissue sampling

4.2 Sampling design

OMP-01 will confirm the distribution of the spill and variation in the characteristics of the hydrocarbon over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP may include:

- Shoreline surveys of mainland (accessible by 4WD) and island (accessible by vessel) coastlines
- Aerial surveys of significant fauna.

Where appropriate baseline data are available, consideration should be given to developing a beyond Before After Control Impact (BACI) monitoring program design (Underwood 1994, 1991), which monitors a range of reference and impact sites over time (i.e. a longitudinal study). Where robust, appropriate baseline data for impact sites are not available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory may be prioritised to obtain baseline data at impact sites prior to hydrocarbon exposure.

Given the distribution of significant fauna in the region of the EMBA, it may not be possible to implement a beyond BACI monitoring program, as significant fauna may be:

- widely distributed with low densities
- seasonally present
- highly localised (e.g. haul out locations for sea lions) with insufficient reference sites available.

In the event that a BACI monitoring program cannot be successfully implemented, a repeated measures design applied to the same site can be used to monitor change over time (particularly if baseline data are available). While the inferences that can be drawn from a repeated measures design are weaker than those of a beyond BACI design, such inferences can still be informative regarding the nature and scale of hydrocarbon spill impacts to significant fauna.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP (4716-HS-H0114) for additional details.

4.2.1 Monitoring sites

The number and types of sites monitored will depend on the design of the monitoring program which is dependent on the size, location and time of year of the spill event, and the potential number of colonies and nesting sites affected. Consideration should be given to key habitat locations where fauna aggregate (e.g. sea lion haul outs) when selecting sites.

Information from OMP-01 and OMP-04 will be used to understand the spill trajectory and the potential exposure of colonies and nesting sites to spilled hydrocarbons. This data will allow the identification of impact sites (all colonies/nesting sites that may have been exposed to hydrocarbons) and reference sites (where applicable).

4.2.2 Monitoring parameters

Table 2 outlines the parameters, methodologies and associated parameters that will be used for SMP-06.

Table 2 – Aspects, methodologies and associated parameters for SMP-06

Aspect	Methodology	Parameter
Evidence of direct impacts of hydrocarbons (e.g. oiling)	Point, transect or areal visual surveys (direct and/or video / photographic) Opportunistic observations during implementation of OMPs / SMPs Tissue / necropsy samples	Counts of individuals by species, noting life-stage (age), health/condition and behaviour, including any injury, oiling or mortality Laboratory analysis of tissue samples for hydrocarbons Inspection of carcasses for evidence of hydrocarbon impacts
Changes in populations	Point, transect or areal visual surveys (direct and/or video / photographic) Opportunistic observations during implementation of OMPs / SMPs	Counts of individuals by species, noting life-stage (age), health/condition and behaviour, including any injury, oiling or mortality

4.2.3 Monitoring frequency and duration

The frequency of monitoring will be determined based on the results of the first round of sampling undertaken in this SMP. Many significant fauna are present seasonally. This seasonality should be considered when determining the timing of additional monitoring.

Monitoring frequency should consider weathering of the spilled hydrocarbon, with frequency decreasing as the rate of change in the spilled hydrocarbon decreases (i.e. monitoring effort is concentrated at the beginning of a spill).

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

4.3.1 Surveys of significant fauna

Surveys of significant fauna consist of counts of individuals via visual observations. Counts of significant fauna should identify animals to the lowest taxonomic resolution possible. Counts should also be made of breeding pairs, offspring (e.g. pups, calves) and juveniles. Note that counts of sea lion pups typically require ground personnel to survey the colony on foot.

Surveys of significant marine fauna can be undertaken from a range of platforms:

- Vessel-based surveys: observers are stationed onboard a vessel
- Airborne surveys: observers are situated onboard an aerial platform such as a helicopter or fixed wing aircraft or camera systems mounted on unmanned aerial vehicles (UAVs)
- Ground-based surveys: observers are ground based, typically on foot. Note that accessing locations for ground-based surveys may require vehicles or vessels to access the survey area. Note that much of the coastline within the EMBA is accessible by suitable 4-wheel drive vehicles.

Each survey method has particular considerations which are discussed below. Note that the most practicable (e.g. cost benefit, safety and logistic considerations) survey method(s) should be used; not all survey methods are required to be implemented.

There are no known nesting beaches or other critical habitats within the EMBA for marine turtles. Therefore, the presence of turtles is expected to be limited to individuals transiting the area.

Vessel and ground-based surveys may provide opportunities to collect animal carcasses for examination. Where carcasses are found, the carcass should be photographed in situ, recovered if practicable, sealed in a plastic bag and stored in refrigerated storage (e.g. cooler with ice bricks). Carcasses should be labelled with the following minimum:

- Date and time
- GPS position
- Sample identification (ID) number, if sample taken
- Image ID number, if images taken
- Person responsible
- Additional comments.

Carcasses should be inspected by suitably competent personnel (e.g. veterinarian) for signs of hydrocarbon exposure and to determine the cause of death. The inspection of carcasses may include assessment of biopsy samples for evidence of hydrocarbon exposure.

Carcasses should be inspected by environmental management agencies or their delegate (e.g. veterinarian) as soon as practicable.

Interactions with significant fauna during surveys may lead to impacts to these fauna. Care should be taken to avoid impacts to significant fauna while achieving the survey objectives. Liaison with wildlife management agencies (e.g. DBCA’s Parks and Wildlife Services) should be carried out prior to undertaking sampling and any permit / licence requirements. Subject matter experts should also be consulted for advice on development and implementation of a sampling program.

4.3.1.1 Airborne Surveys

Airborne surveys can be carried out from helicopters or fixed wing aircraft. Sightings and positions of significant fauna will be recorded by competent observers along pre-determined strip-transects within the area of impact as well as reference sites, and will target key breeding, feeding, foraging and habitat areas where possible. Transect size and orientation will be determined by logistics (e.g. aircraft endurance) and scientific considerations. Density and abundance can be estimated from the count of individuals within a fixed width for any portion of a transect.

Where practicable, counts should be independently carried out by more than one observer while sampling along transects to facilitate comparisons between observers (e.g. two observers on one side of a fixed wing aircraft). In addition to counts from observers, video or photographic images should also be recorded to allow additional counts to be made after completion of the flight.

While flying at lower altitude may facilitate counts of significant fauna, the noise disturbance to significant fauna should be considered prior to undertaking airborne surveys. Airborne sampling also requires additional safety consideration.

Larger fauna that spend time at the surface or in shallow waters (e.g. whales) are generally more suited to counts during airborne surveys. Smaller fauna or fauna that do no spend time at the surface may not be suitable for monitoring using airborne surveys.

4.3.1.2 Vessel-based Surveys

Vessel-based surveys will provide data on the distribution of significant fauna at sea. Vessel surveys should sample along pre-determined strip transects as observers utilise optical equipment such as a spotting scope or binoculars to record significant fauna observations. Observers will record the following:

- counts of significant fauna (identified to lowest practicable taxonomic resolution)
- locations of significant fauna
- photographs / videos (where practicable – note humpback whales)
- animal behaviour
- evidence of impacts from hydrocarbons (e.g. oiling, injury, mortality).

Transect details (start/end points) should be captured at each survey location using a GPS. Where possible, photographs will be taken to assist in the species identification and counts. General meteorological observations will also be made at the time of survey, including temperature, precipitation, wind direction and strength and visibility.

Vessel-based surveys can also be used to survey the shoreline at sea lion haul out sites where access via land is restricted and offshore. Observers on the vessel will collect observations on sea lions, and will collect GPS data for sightings and record data on data sheets. Each transect should be completed twice, with observations made each time. Data will include assessments of significant fauna abundance, spatial distribution and any indications of direct hydrocarbon exposure.

Observers should be situated as high as possible on the vessel (e.g. on the bridge or flybridge) to facilitate detection when undertaking vessel based surveys. Cetaceans may be detected by sightings of blows (i.e. animals breathing on the surface), which may be characterised by water spray.

4.3.1.3 Ground-based surveys (sea lions)

Ground-based surveys may be suitable for counts of sea lions at haul out sites. Note that ground-based surveys may result in behavioural disturbance to sea lions; consideration of the necessity for ground-based surveys of sea lions should be discussed with wildlife management agencies (e.g. DBCA) and subject matter experts. In particular, measures relying on direct interaction with animals (e.g. cumulative mark and count studies) should be carefully considered. Note that where such studies are carried out in a beyond BACI experimental design, it is important to include a procedural control (i.e. the cumulative mark and count technique should be applied as a method control).

Note that shore-based observations of other significant fauna (particularly whales) can be made from shore; however such observations are restricted to animals relatively close to shore. As such, vessel or airborne surveys are preferred.

<u>Haul out sites</u>

An accepted count technique for sea lions is to undertake a direct count of newborn pups at breeding colonies, as this is the only age class guaranteed to be on land and available at one occasion. Additionally, pups generally remain ashore when disturbed during or at the end of the pupping season. Trends in pup production can be used as an indicator of the change in population over time.

Counts can also be undertaken to assess impacts at haul out sites remote from the haul-out site itself (e.g. airborne, vessel, look out location) to avoid disturbance of sea lions which are highly mobile and often leave the haul out site when disturbed.

A ‘direct count’ method can be used where all sea lions visible will be counted. This will either be done through visual counts from airborne surveys, a vessel or land based (e.g. cliff look out) survey. In the event that airborne surveys are undertaken simultaneous with the real time counts, oblique photographs should be taken to corroborate the counts.

Breeding colonies

Because of the long breeding season of Australian sea lions (up to 7 months), by the end of the pupping season some pups may have dispersed or moulted (and therefore may go unrecognised). Therefore, a cumulative mark and count method will be used to estimate pup numbers. This method is best for smaller colonies (<40 pups), which represents most of the breeding colonies in Western Australia (Goldsworthy et al. 2009, 2008, Shaughnessy et al. 2011). Observers will catch pups and each will be given a mark by clipping a patch of hair on the back. The number of marked, unmarked and dead pups sighted will be recorded on each visit and additional (previously unmarked) pups marked. Again, a separate count will be undertaken for dead pups; any dead pups will be marked to prevent recounting in subsequent surveys.

4.4 Data management

4.4.1 Field data management

Field data will be recorded on data sheets during monitoring. Information will be recorded on each data sheet, including, but not limited to:

- Date and time of sampling
- Site reference, sample/survey type and code/number
- AV equipment model, type, ID#; memory card ID#
- Digital filenames (or name-number range)
- GPS position
- Species
- Abundance
- Life-stage (age)
- Behaviour
- Health/Condition
- Hydrocarbon exposure
- Breeding activity
- Person responsible
- Additional comments.

Digital field data (e.g. video and photographs) should be downloaded as soon as practicable following retrieval of the instrument and backed up onto independent storage (e.g. universal serial bus (USB) drives). Photographs should be named and stored using a system that clearly links images to sites and facilitates storage, retrieval and back up. Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. portable drives). All written data sheets should be stored securely. All data in digital should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

4.4.2 Office data management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and backed up to independent digital storage. Data should be managed and stored in accordance with TEO's Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.5 Quality control

4.5.1 Equipment

All equipment will be checked prior to mobilisation (Section 3.2).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or data integrity.

4.5.2 Samples

Recovered carcasses should be checked to ensure they are correctly labelled and provided to environmental management agency (e.g. wildlife officer) or their delegate. All samples should be accompanied by a CoC form.

4.5.3 Data management

4.5.3.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the portable hard drive. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation. An electronic metadata summary will be completed which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for any laboratory samples to be returned to Perth (TEO West Perth office). Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to being sealed in the cooler with the samples for transport.

Taxonomic assessments should be routinely cross checked to ensure that species are identified accurately.

4.5.3.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

4.5.4 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, health, safety and environment performance, etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets suitable for use in other SMPs
- Reports detailing the impacts (if any) on significant fauna as a result of a hydrocarbon spill. Reports should contain descriptive statistics of data collected and suitable comparisons between data sets (e.g. ongoing monitoring, reference and baseline data, etc.). Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated and the same results obtained by a competent third party unfamiliar with the monitoring program.

Where reference and baseline data are available, data analysis should compare impact sites to references sites while considering baseline data. Where either baseline or reference data are not available, data from impact sites should be compared over time. Data analysis should consider measures of species abundance and diversity (i.e. counts of species) and breeding success (numbers of calves/pups, survival of calves/pups).

Data from other OMPs and SMPs are available that may inform data analysis (e.g. spatial extend of hydrocarbon contamination) should be considered, where applicable. Data analysis should also consider the termination criteria for the SMP.

6 References

Goldsworthy, S., McKenzie, J., Shaughnessy, P., McIntosh, R., Page, B., Campbell, R., 2009. An update of the report: Understanding the impediments to the growth of Australian sea lion populations (SARDI Research Report Series No. 356). South Australian Research and Development Institute, Adelaide.

Goldsworthy, S., Shaughnessy, PD, Page, B., Lowther, A., Bradshaw, C., 2008. Developing population monitoring protocols for Australian sea lions: enhancing large and small colony survey methodology (SARDI Research Report Series No. 297). South Australian Research and Development Institute, Adelaide.

Shaughnessy, P., Goldsworthy, S., Hamer, D., Page, B., McIntosh, R., 2011. Australian sea lions *Neophoca cinerea* at colonies in South Australia: distribution and abundance, 2004 to 2008. Endangered Species Research 13: 87–98. doi:10.3354/esr00317

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological Applications* 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix B.7 SMP07 - Scientific monitoring of fisheries and tourism resources (4716-HS-H0114-17)

SMP-07 - Scientific Monitoring of Fisheries Resources

Triangle Energy (Operations) Pty Ltd Controlled Document

4716-HS-H0114-17

Revision: 1

Issue date: 04/10/2022

Document control and revisions

This SMP-07 - Scientific Monitoring of Fisheries Resources for the Cliff Head Project is a controlled document.

The TEO HSE & Regulatory Manager is responsible for controlling this document and any revisions to it. Responsibility for managing change in this document is detailed within the Cliff Head Management of Change Procedure (MoC) (10HSEQGENPC18).

Should the recipient or user become aware of any changes or corrections that are required please photocopy this page, with completed details, and the relevant pages to be changed, note the corrections and deliver them to:

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This SMP-07 - Scientific Monitoring of Fisheries Resources shall be revised in the following circumstances:

- after a period of five years
- on discovery of a significant new environmental effect or risk
- with a significant change to the operation.

Revision History

1	04/10/2022	Issued for use	ERM	J Chidlow	B Donaldson
0	28/04/2016	Issued for use	A Badri	Chris Fu	G Napier
Rev	**Issue date**	**Revision summary**	**Originator**	**Reviewer**	**Approver**

Approvals

This SMP-07 - Scientific Monitoring of Fisheries Resources has been reviewed by Triangle Energy (Operations) Pty Ltd and is approved for the Cliff Head Project.

Approval: Triangle Energy (Operations) Pty Ltd

Name	Signature	Date
Name: Bryce Donaldson Position: Manager HSE & Regulatory Triangle Energy (Operations) Pty Ltd		04/10/2022

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4	Simon Price, PIC (TEO)
5	Rob De Roach, Environment Team Lead (BMT)

Table of Contents

References

Document code	Title
10HSEQENVPL01	Cliff Head Offshore Operations Environmental Plan
10HSEQENVPL02	CHA Operations Oil Spill Contingency Plan
10HSEQENVPC06	Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure
10HSEQENVPL11	Cliff Head Field State Offshore Environment Plan
10HSEQENVPL15	CHA Operations Oil Pollution Emergency Plan
4716-HS-H0114	Cliff Head Project Operations Overarching Operational and Scientific Monitoring Program
4716-HS-H0114-01	OMP-01 – Oil Distribution Monitoring – Sea Surface, Shorelines and Water Column
4716-HS-H0114-02	OMP-02 – Oil Character and Fate Modelling
4716-HS-H0114-03	OMP-03 – Shoreline Assessment
4716-HS-H0114-04	OMP-04 – Wildlife Impact Monitoring
4716-HS-H0114-05	OMP-05 – Response Strategy Monitoring
4716-HS-H0114-11	SMP-01 - Scientific monitoring of hydrocarbons in marine waters (including weathering)
4716-HS-H0114-12	SMP-02 - Scientific monitoring of hydrocarbons in marine sediments
4716-HS-H0114-13	SMP-03 - Scientific monitoring of shoreline and intertidal benthos
4716-HS-H0114-14	SMP-04 - Scientific monitoring of subtidal benthos
4716-HS-H0114-15	SMP-05 - Scientific monitoring of seabirds and shorebirds
4716-HS-H0114-16	SMP-06 - Scientific monitoring of sea lions, cetaceans and turtles
4716-HS-H0114-17	SMP-07 - Scientific monitoring of fisheries resources

Term Definitions and Abbreviations

Term or abbreviation	Definition
4WD	Four Wheel Drive
BACI	Before-After Control-Impact
BTEX	Benzene, toluene, ethylbenzene and xylene
CHA	Cliff Head Alpha
CoC	Chain of custody
DPIRD	Department of Primary Industries and Regional Development
EMBA	Environment that may be affected
GC-MS	Gas chromatography-mass spectroscopy
GPS	Global positioning system
GSI	Gonado-somatic index
HPLC	High performance liquid chromatography
ID	Identification
IMS	Invasive Marine Species
JHA	Job hazard analysis
LSI	Liver somatic index
MSDS	Material Safety Data Sheet
OMP	Operational monitoring plan
OPEP	Oil Pollution Emergency Plan
OSCP	Oil Spill Contingency Plan
OSMP	Operational and scientific monitoring plan
PAH	Polycyclic aromatic hydrocarbon
PPE	Personal Protective Equipment
SDH	Serum sorbitol dehydrogenase
SMP	Scientific monitoring plan
TEO	Triangle Energy (Operations) Pty Ltd
TPH	Total petroleum hydrocarbons

1 Rationale

The rationale and purpose of scientific monitoring plan 07 (SMP-07) is to quantify the potential contamination and tainting of fisheries resources (including finfish, elasmobranchs, shellfish and crustaceans) exploited by commercial and recreational fishers from hydrocarbon exposure/contact. Information from this SMP will be used to assess the suitability of seafood for human consumption, which may affect subsequent socio-economic impacts to fishers.

1.1 Objectives

The objectives of SMP-07 are to:

- Assess fisheries resources for hydrocarbon contamination
- Assess any physiological impacts to fisheries resources and if applicable, seafood quality and safety
- Provide information that can be used to make inferences on the health of fisheries and the potential magnitude of impacts to fishing industries (commercial and recreational).

2 Decision-making inputs and outputs

2.1 Inputs from other plans

In order to inform the initiation and design of SMP-07, the following inputs will be required:

- Current and previous distribution of hydrocarbons from the spill (operational monitoring plan (OMP-01 (4716-HS-H0114-01))
- The predicted spill trajectory (OMP-01 (4716-HS-H0114-01))
- Evidence of contact with fisheries resources during operational response (OMP-04 (4716-HS-H0114-04))
- Areas known to or expected to host fisheries resources.

2.2 Outputs to other plans

The data and analysis associated with SMP-07 is not used to inform decision making in relation to other SMPs or OMPs. The outputs will be used to determine whether the termination criteria for this SMP have been achieved.

2.3 Key environmental receptors

A range of commercial fisheries operate in the region of the Cliff Head project, the most significant of which is the western rock lobster fishery. The western rock lobster forms the basis of a Key Ecological Feature identified in the Marine Bioregional plan for the South-west marine region (Department of Sustainability, Environment, Water, Population and Communities 2012). Other fisheries resources include demersal scale fisheries (including prized species such as Western Australian dhufish, baldachin grouper and snapper) and pelagic species such as tailor and pilchards.

Aquaculture development in the region is focussed around the Houtman Abrolhos islands, which has been identified as a strategic aquaculture development zone by the State government.

2.4 Relevant environmental data

Existing environmental data relevant to this SMP, including analytical water quality data, are available from the Cliff Head environmental data directory:

TEO Server: \\Wau-per-dc1\waus\PERTH\ASP_OPERATIONS\6) HSEQ\17) Environmental\OSR_Enviro_Data

2.5 Initiation criteria

The initiation criteria for SMP-07 comprise:

- Operational monitoring indicates that contact with fisheries resources has occurred or is likely.

2.6 Termination criteria

The termination criteria for this SMP comprise:

- The level of impact to affected fish and shellfish populations has been quantified
  OR
- The impacts to important fisheries resources are not significantly different to reference areas or baseline
  OR
- The impacts of the hydrocarbon spill are no longer statistically detectable.

3 Pre-mobilisation activities

Note that fisheries resources in Western Australian state and Commonwealth waters are managed primarily under the *Fish Resources Management Act 1994*. Collection of fisheries resources may be subject to the requirements of this Act and related legislation. Collection of fisheries resources for this SMP should be carried out by an appropriately licenced fisher (e.g. a licenced commercial fisher or holder of a scientific collection permit). Note that the application for a scientific collection permit may be subject to a fee and take several weeks to be granted. As such, collection via a suitably licenced commercial fisher may be preferable.

The following should be considered prior to mobilising scientific resources to implement this SMP in the field.

3.1 Personnel

In addition to the generic staff requirements described in the overarching operational and scientific monitoring plan (OSMP) (4716-HS-H0114), staff required to implement SMP-07 should hold the following qualifications and competencies:

- Senior marine scientist(s) – to design the monitoring program design and implement the program in the field
- Marine scientist(s) – to undertake SMP under the direction of senior marine scientist
- Commercial fishers – to collect fisheries resources under existing managed fishery licences (unless other valid authority to collect fisheries resources is in place)
- Sensory analysts – to participate in sensory perception (taste and smell) testing of seafood samples for hydrocarbon taint.

Access to fisheries may require vessels or vehicles and therefore, additional team members and qualifications required (e.g. offshore medical, four wheel drive/off-road training).

3.2 Equipment

In addition to the generic equipment outlined in the overarching OSMP (4716-HS-H0114), the following equipment is required for SMP-07:

- 4WD Vehicle
- Aluminium foil
- Balance (accurate to 0.01 g)
- Centrifuge (take care when using centrifuges on vessels due to instability)
- Chain of Custody (CoC) sheets
- Clapper board (or similar) for photo identification
- Communications (e.g. mobile or satellite telephone, radios)
- Coolers / liquid nitrogen dewars for sample transport
- Digital camera(s) (including spare memory card and battery)
- Dissection kit (scalpels, scissors, hypodermic needles, syringes etc.)
- Fishing equipment (lines, traps, bait etc.) suitable for target species
- Glutaraldehyde (or other suitable fixative)
- Handheld GPS
- Hexane
- Job Hazard Analysis (JHA)
- Laboratory address labels
- Latex gloves
- Material Safety Data Sheets (MSDS) for all chemicals
- Plastic sample bags (e.g. snap lock)
- Refrigerated sample storage (e.g. refrigerator, coolers with ice bricks)
- Vessel(s) suitable for deployment.

3.2.1 Preparation

The following activities will need to be undertaken, to ensure equipment is in working order, prior to mobilisation to the field:

- Develop sampling program consistent with principles in the overarching OSMP, this SMP and available existing data
- Liaise with fisheries management agencies (e.g. Department of Primary Industries and Regional Development (DPIRD)) to determine permitting requirements (unless procuring fisheries resources through a licenced fisher)
- Confirm equipment resources and availability to implement the sampling design as per the monitoring program
- Confirm all GPS units and cameras are in good working order and that sufficient spare batteries and memory cards are available
- Check field laptops, confirming that they have batteries, power cable, licenses, logins, have relevant software
- Confirm GPS survey positions (where available) have been checked and pre-loaded into navigation software/positioning system
- Sampling equipment checked to confirm that it is in good working order and has been calibrated
- All spatial information is to be recorded in eastings and northings using the Map Grid of Australia (MGA) Zone 50 coordinate reference system (CRS) and the Geodetic Datum of Australia 2020 (GDA2020).

3.3 Logistics

Upon notification that SMP-07 has been triggered, the following activities will be undertaken as part of the pre-mobilisation phase:

- Assemble competent field team (refer to Section 3.1 and Overarching OSMP), including required personal protective equipment (PPE)
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Arrange transportation for field staff and equipment to the site
- Arrange suitable vessel(s) for monitoring operations, ensuring that invasive marine species risk for vessels (and submerged equipment) is managed in accordance with Cliff Head Invasive Marine Species (IMS) Risk Assessment Procedure (10HSEQENVPC06)
- Contact fisheries / aquaculture farms where samples need to be collected
- Liaise with fisheries management agencies (e.g. DPIRD) to determine permitting requirements (unless procuring fisheries resources through a licenced fisher).
- Define and communicate departure and in-field rendezvous points to all personnel and third-party service/equipment providers
- Liaise with National Association of Testing Authorities (NATA) certified laboratories regarding analytical services
- Obtain required inputs from other plans and facilitate ongoing communication with other plans (Section 2.1)
- Confirm monitoring design and continually update as new situational awareness information becomes available
- Arrange accommodation for field staff
- Develop and implement JHA and TEO Oil health, safety and environmental management system requirements
- Prepare survey maps using spatial data resources (e.g. Oil Spill Response Atlas)
- Procure and collate field consumables and equipment (refer to Section 3.2)
- Arrange transportation for collected samples from field to laboratory

Refer to the overarching OSMP (4716-HS-H0114) for additional information on logistical considerations.

4 Methodology

4.1 Monitoring Strategy

SMP-07 will monitor fisheries resources in areas at risk from hydrocarbon spill exposure and spill response activities as well as in non-oiled reference areas. Table 1 summarises the monitoring parameters that will be used to assess the impact and recovery of fisheries resources in the event of a hydrocarbon spill.

Pre-impact data should be collected in conjunction with other OMPs and SMPs to increase efficiency and make best use of available resources. Any pre-contact data collected as part of early surveillance and survey activities should be utilised in this scientific monitoring program. Where practicable, monitoring sites for this SMP should be coordinated with those of other OMPs and SMPs to generate efficiency in the field. This also may assist in analysis and interpretation of other monitoring programs.

Table 1 – Environmental sensitivities, aspects and methodologies for SMP-07

Environmental sensitivity	Aspect	Methodology
Fisheries resources, including: • Western rock lobster • Demersal scalefish • Pelagic scalefish • Elasmobranchs • Aquaculture resources	Evidence of direct impacts from hydrocarbons (e.g. fish kills) Fitness for human consumption Changes in fish resource stocks	Seafood taint assessment Laboratory analysis of biopsies Stock assessments

4.2 Sampling Design

SMP-01 will confirm the distribution of the spill and variation in the characteristics of the hydrocarbon over time. This information can assist in developing other SMPs. Methodologies to be implemented during the execution of this SMP may include:

- Vessel based fishing using methods suitable for the target species (e.g. baited pots for western rock lobster, baited lines for demersal scalefish)

Where appropriate baseline data are available, consideration should be given to developing a beyond Before After Control Impact (BACI) monitoring program design (Underwood 1994, 1991), which monitors a range of reference and impact sites over time (i.e. a longitudinal study). The Western Australian DPIRD should be consulted with regard to the availability of existing fisheries data. Where robust, appropriate baseline data for impact sites are not available, pre-exposure sampling of locations that lie within the hydrocarbon spill trajectory may be prioritised to obtain baseline data at impact sites prior to hydrocarbon exposure.

In the event that a BACI monitoring program cannot be successfully implemented, a repeated measures design applied to the same site can be used to monitor change over time (particularly if baseline data are available). While the inferences that can be drawn from a repeated measures design are weaker than those of a beyond BACI design, such inferences can still be informative regarding the nature and scale of hydrocarbon spill impacts to significant fauna.

Statistical power should be considered when developing the sampling design to control the type II error rate of statistical analyses. Refer to the overarching OSMP (4716-HS-H0114) for a discussion of statistical power.

Impact sites should be selected first, with impact encompassing a representative selection of marine sediments within the environment that may be affected (EMBA) from a hydrocarbon spill. Note that multiple impact sites should be selected to facilitate analysis. Comparable reference sites beyond the EMBA should then be selected, with monitoring conducted at all sites. Refer to monitoring program design discussion in the overarching OSMP (4716-HS-H0114) for additional details.

Fish hydrocarbon taint assessment should be carried out as a blind tasting (i.e. the assessor is not aware of whether the sample has been exposure to hydrocarbons).

Stock-level assessments should be carried out in conjunction with the Western Australian DPIRD.

4.2.1 Monitoring sites

The number and types of sites monitored will depend on the design of the monitoring program which is dependent on the size, location and time of year of the spill event, and the fish resources potentially affected. Consideration should be given to examining fish resources that may be available from commercial fishers and aquaculture producers.

Priority should be given to target commercial and recreational fish species when selecting target fish species for SMP-07. The number of species selected should be determined in consultation with stakeholders such as the DPIRD.

Aquaculture sites affected by the spill should be considered as required. The nearest aquaculture facilities to the Cliff Head development are considered to be extremely unlikely to be affected by a hydrocarbon spill (i.e. near the Houtman Abrolhos islands >100 km from Cliff Head platform).

Information from OMP-01 and OMP-04 will be used to understand the spill trajectory and the potential exposure of fisheries resources to spilled hydrocarbons. This data will allow the identification of impact sites and reference sites.

4.2.2 Monitoring parameters

Table 2 outlines the parameters, methodologies and parameters that will be used for SMP-07.

SMP-07 is intended to assess the impact on fisheries resources; as such the suite of target species to be assessed should be determined in consultation with commercial and recreational fishers that exploit fisheries resources within the area affected by a hydrocarbon spill. The principal commercial fishery in this region is the western rock lobster fishery, which is Australia's most valuable single-species wild capture fishery. As such, western rock lobster should be considered in any monitoring program developed for SMP-07.

Table 2 – Monitoring parameters, methodologies and associated parameters for SMP-07

Aspect	Methodology	Parameter
Evidence of direct impacts from hydrocarbons (e.g. fish kills)	Laboratory analysis of biopsies	Fish health indicators and biomarkers including: • Liver detoxification enzymes (EROD activity) • Polycyclic aromatic hydrocarbon (PAH) Biliary Metabolites • Oxidative deoxyribonucleic acid (DNA) damage • Serum Sorbitol Dehydrogenase (SDH) activity. Hydrocarbon contamination and physiological impacts of exposure including: • Liver somatic index (LSI) • Gonado-somatic Index (GSI) • Gonad histology • Total weight • Total length • Condition • Parasites • Any abnormalities.

Fitness for human consumption	Seafood taint assessment Laboratory analysis of biopsies	Sensory assessment (taste, smell etc.) Chemical Analysis of gut and tissue: • Total Petroleum Hydrocarbons (TPH) • PAHs • Benzene, Toluene, Ethylbenzene and Xylene (BTEX) • Metabolites of aromatic compounds by high performance liquid chromatography (HPLC) or gas chromatography-mass spectroscopy (GC-MS).
Changes in fish resource stocks	Stock assessments	To be conducted in consultation with DPIRD – requires catch and effort and puerulus settlement data collected by the department

4.2.3 Monitoring frequency and duration

An initial round of sampling should be conducted as soon as practicable following the initiation criteria in Section 2.5 being met.

The frequency of monitoring will be determined based on the results of the first round of sampling undertaken in this SMP. Appropriate monitoring frequency and duration might be readjusted depending on:

- Hydrocarbon release conditions such as hydrocarbon type and volume spilled
- Species exposed and exposure duration. For example, finfish generally eliminate hydrocarbons within days or weeks. However, lifestyle might expose some species for longer periods, e.g. fish associated with the ocean floor might be exposed to contaminated sediments for a longer time relative to fish living in the water column.

In relation to the tainting studies, as finfish do not accumulate petroleum hydrocarbons in their edible flesh, monitoring for less than one month after a hydrocarbon release will be sufficient if the hydrocarbon was light but longer if heavy. Invertebrates, however, do not depurate hydrocarbons as quickly so monitoring will continue until no trace of tainting could be detected.

The duration of the SMP will depend on the time taken to reach the termination criteria (Section 2.6). The requirement for ongoing monitoring will be reassessed following each round of sampling undertaken under this SMP, with monitoring to be terminated when hydrocarbon levels at impact sites are consistent with hydrocarbon concentrations at reference sites.

4.3 Sampling procedure

The collection of consistent samples during the execution of the survey is required. This will be achieved through standardised procedures which are summarised in Table 3.

Table 3 – Standardised methodology for each sampling procedure

Sampling Methodology	Standardised Procedure
Commercial fisheries	Target species Adult specimens Biopsies conducted on freshly sacrificed animals
Recreational fisheries	Adult specimens Biopsies conducted on freshly sacrificed animals
Aquaculture facilities	Fish sample procedures as per above for recreational fisheries Bivalve samples dissected, tissues removed and stored in food grade plastic bags and frozen at -20°C

Sampling Methodology	Standardised Procedure
Seafood tainting	Targeted species used Muscle samples wrapped in hexane-rinsed aluminium foil, placed in food grade plastic seal bags, labelled and immediately frozen at -20°C Olfactory testing done using duo-tri method Blue-green lights used in sensory booths to mask colour Fish portions standard size and thickness Presented on white china plates Each sample assessed raw and cooked

4.3.1 Commercial fisheries

Samples of commercial fishes may be obtained from licenced fishers, either by commissioning the licence holder to collect the fish directly (preferable), or by purchasing fish from licenced fishers portioning in the area. If purchasing fish, the location at which the fish were caught must be clearly identified with a high degree of confidence. The collection method should be suitable for the target species and may include:

- Baited pots (for western rock lobster)
- Baited lines (finfish).

At target of twenty fish per species within each impact and reference areas should be collected where possible. All specimens collected should be adults. Where possible, fish should be kept alive in tanks equipped with flow through water, as biopsies need to be collected on freshly killed animals. Upon capture all fish will be identified, measured for length, weighed and examined externally for any visible signs of physical stress. Any abnormality will be photographed and recorded. The sex and reproductive stage will also be recorded.

Prior to dissection fish will be killed by iki jime (spike through the brain). The specific type of sample to be collected from each fish, its analysis purpose and storage requirements are outlined in Table 4.

Table 4 – Fish sampling collection summary

Sample Collected	Number Of Samples	Analysis Type	Handling And Storage
Blood sample from caudal vein	1 per animal	Sorbitol dehydrogenase activity	Sample coagulates at 4°C for 20 minutes Sample centrifuged for 10 minutes Half of serum frozen at -20°C Half of serum placed in liquid nitrogen
Dissected along ventral line	1 per animal	Examination for internal parasites	Visual investigation and record of parasites found
Bile from gall bladder	1 per animal	Biliary metabolites	Collected using 1 ml syringe Sample Frozen at -20°C
Liver	1 per animal	Liver somatic index Histology	Sample weighed Subsamples frozen in liquid nitrogen
Gonads	1 per animal	Gonadosomatic index Histology	Sample weighed Preserved in glutaraldehyde for histology
Carcass	1 per animal	Body less viscera weight	Sample weighed
200 g muscle tissue	1 per animal	Hydrocarbon analysis	Wrapped in HPLC-grade aluminium foil rinsed with hexane and placed in a press seal food grade plastic bag Frozen at -20°C or less
400 g muscle tissue	1 per animal	Taste or olfactory test (Section 4.3.4)	
Gut Samples*	1 per animal	Hydrocarbon analysis	

Note * Stomach contents of demersal fish could be biased due to bait in traps, therefore stomach contents from demersal fish will only be collected if it is identified as 'other than bait'. Stomach and intestine contents will be collected from all pelagic fish.

4.3.1.1 Sample labelling

All samples should be pre-labelled or labelled immediately following sealing of the container with indelible marker. Sample containers will be clearly labelled with the following information as a minimum:

- Unique sample identification (ensure that the sample identification is clearly recorded in the field data sheet). This sample identification should be unique, unambiguous and clearly linked to the sampling site
- Analytical parameter(s)
- Sample collection time and date
- Project specific job number.

4.3.1.2 Storage and transport

Samples must be handled, stored and transported with care to avoid contamination. Samples should be collected and sent to the specified laboratory for analysis in accordance with holding times wherever practicable. Liaise with the analytical laboratory for information on holding times.

Samples should be packed securely into suitable dewars or freezers for delivery to each laboratory. Chain of Custody (CoC) forms should be completed and accompany all analytical samples following collection. Whenever samples change hand (e.g. from field team to courier, from courier to analytical laboratory) the CoC should be updated to reflect this.

The specific requirements for the storage of each sample to be collected is summarised in Table 4.

4.3.2 Recreational fisheries

Sampling to obtain fish targeted by recreational fishers will be undertaken by targeted fishing surveys conducted by a survey team at impact and reference locations. Note that species targeted by both commercial and recreational anglers should be collected by commercial fishers where practicable. As such, recreational target species are expected to be collected primarily by shore based angling.

Due to variability in catch associated with recreational fisheries and the methods being used, it may be difficult to select target species for the survey. Therefore, this survey will aim to collect between 80 and 100 fish in total. Upon capture, all fish will be identified and examined externally for any visible signs of physical stress and measured. Any abnormality will be photographed and recorded. The sex and reproductive stage will also be recorded.

The samples from each fish, including analysis and storage requirements, are outlined in Table 4.

4.3.3 Aquaculture facilities

If aquaculture facilities have been contacted or are likely to be contacted, then targeted monitoring will occur. A total of 20 animals of the cultured species should be collected for analysis. The collection of samples from fish in aquaculture facilities will be treated as described in Table 4.

4.3.4 Seafood tainting

Olfactory analysis will be conducted on seafood resources collected from impact and reference sites. Targeted exploited species will be selected within relevant size classes from suitable indicator species from the region under investigation. Samples will be acquired in conjunction with the commercial and recreational fisheries sampling programs (refer to Section 4.3.1).

Muscle tissue samples will be collected at each sampling location, wrapped in hexane rinsed aluminium foil and placed in food-grade plastic seal bags, labelled and immediately frozen at -20°C or less. A minimum of ten specimens per species per sampling location will be collected.

Olfactory testing will be conducted using the duo-tri method in accordance with Australian Standards (Sensory analysis, Part 2.4: Methodology - Duo-trio test. AS 2542.2.4:2014). Using this method, panellists will be asked to identify which samples of two (one impact and one reference) is most similar to a control sample (either impact or reference).

4.4 Data Management

4.4.1 Field Data Management

Field data will be recorded on data sheets during monitoring. Information will be recorded on each data sheet, including, but not limited to:

- Date and time of sampling
- Sample site reference code/number
- GPS position
- Counts of species captured
- Evidence of oiling
- Person responsible
- Additional comments.

Digital field data (e.g. video files, photographs) should be downloaded as soon as practicable and backed up onto independent storage (e.g. portable hard drives). Written field data should be entered into digital format at least daily (e.g. transcribed into spread sheets, hard copies scanned) and backed up onto independent storage (e.g. USB drives). All written data sheets should be stored securely. All data in digital format should be transmitted off site for additional data security where practicable (e.g. to TEO West Perth office for storage on network drives).

Summaries of samples collected for all locations visited will be included in standard daily field reports from field teams to TEO.

4.4.2 Office Data Management

All field data received from the field team (either during monitoring or following demobilisation) should be stored digitally and backed up on independent digital storage. Data should be managed and stored in accordance with TEO’s Data Governance Manual. Refer to the overarching OSMP (4716-HS-H0114) for additional information on data management.

All data sets will be accompanied by a metadata summary (refer to overarching OSMP for additional information on metadata summaries).

All data analysis should be undertaken on copies of original data, with the original data unaltered.

4.5 Quality Control

4.5.1 Equipment

All equipment will be checked prior to mobilisation (Section 3.2).

Whilst in the field, equipment will be checked during daily pre-starts and regularly given a visual assessment throughout the day to ensure it is functioning correctly. Lost time due to equipment malfunction, including the issues/causes of the malfunction, will be documented in order to identify any potential consistent faults, or those that may have potential to affect health and safety and/or sample integrity.

4.5.2 Samples

Following collection of sediment samples, the following should be checked:

- Correct sampling site
- Correct sampling equipment (and when last decontaminated) and containers used
- Sufficient volume sampled

- GPS position and time recorded when sample taken
- Evidence of contamination (e.g. damaged or ill-fitting bung, anthropogenic material in sample)
- Latex gloves to be worn whilst handling sediment sampling equipment. Gloves should be changed between each sampling location
- Potential anthropogenic contaminants (e.g. sun cream, smoking/smokers, sweat, hydrocarbons from exhaust gases, fuel or cleaning agents) are to be avoided by the personnel in contact with the sediment sampling equipment

Fish and shellfish specimens should be checked to ensure they are correctly labelled and provided to environmental management agency or their delegate. All samples should be accompanied by a CoC form.

4.5.3 Data

4.5.3.1 Field

Field data sheets should be retained and checked to ensure that all fields have been completed and that writing is clearly legible. Information transcribed from field data sheets into electronic format should be checked for accuracy and completeness.

The storage temperature of sediment samples should be checked at the beginning of each shift. For 12-hour operations, this may be undertaken at both the start and the end of each shift.

All photographs should be checked to ensure they are clearly linked to the sites at which they were taken (e.g. by labels being legible in the photo).

All digital data will be checked to confirm that the files open, are downloaded and backed up on to duplicate external hard drives. The files on the hard drive will also be checked to confirm that they open correctly before original data are deleted from the water quality profiler. On site digital data will be transferred back to the TEO office by field survey personnel during demobilisation.

Before sending any data to the office, an electronic metadata summary will be completed (and included with the data package) which records the file names for each digital data file, the time and date it was collected, its storage location and the personnel responsible for quality control.

CoC forms will be completed for each cooler of samples to be returned to Perth. Each cooler will contain samples going to a single laboratory only, and the CoC will be in the format required by that particular laboratory. CoC forms will be checked upon completion, prior to being sealed in the cooler with the samples for transport.

4.5.3.2 Office

Digital files received from the field will be checked against the electronic metadata summary to make sure that all the files listed have been received. Files will be saved and backed up in the office and these files will be checked to make sure that the backup has been successful, the backup file is not corrupt and that the files can be opened.

4.6 Data analysis

All analyses should be carried out on a duplicate data set; original monitoring data should not be altered during the analysis.

Upon receiving the analytical results from a laboratory, the results should be reviewed for outliers and an assessment of the quality of the analysis made by a competent scientist. This assessment should be documented in the reporting on fisheries resources and any discrepancies discussed.

5 Reporting

5.1 Injured/oiled wildlife

If a scientific monitoring team detect any fauna that appears injured by hydrocarbons or spill response activities, the scientific team shall promptly seek advice from the Wildlife Coordinator to ensure a prompt and appropriate animal welfare response.

5.2 Data Reporting

Once field sampling has been completed and data has been analysed and interpreted, the following reporting to TEO should be carried out:

- Daily field survey reports detailing activities undertaken, HSE performance etc.
- All sampling and analysis data provided in spatial data format (e.g. shape file) and spread sheets.

The biopsies taken from commercial and recreational fish resources will be used to measure following biochemical markers, each of which will be assessed in the reporting or evidence of hydrocarbon related impacts:

- Liver detoxification enzymes: The petroleum hydrocarbons absorbed by the fish are metabolised by the liver using detoxification enzymes. These are quantified in the liver
- PAH biliary metabolites: Petroleum compounds are directed to the bile for elimination out of the body. Biliary metabolites (e.g. naphthalane metabolites, pyrene metabolites and benzo(a)pyrene metabolites) of petroleum compounds represent the most sensitive biomarker of exposure to crude oil, and can inform on the temporal and geographical extent of the exposure to very low levels
- Oxidative DNA Damage: Several contaminants, including petroleum compounds, can alter the integrity of the DNA molecule. This biomarker evaluates the oxidative damage done to the DNA molecules via the quantification of the 8-oxo-DG protein
- Serum SDH: Serum sorbitol dehydrogenase informs on liver integrity and liver functions, which might be affected if exposure is high.

The seafood taint assessment will include a statistical assessment of the sensory analyses conducted, with a determination made on whether evidence of hydrocarbon taint is detectable.

Summary statistics and statistical analyses can be conducted in a range of software packages, including spread sheets (e.g. Excel) or statistical packages (e.g. Systat, SPSS, R, Primer). When undertaking statistical analyses care should be taken to ensure that all assumptions and limitations with a particular test or method are clearly understood and documented.

All data analysis should be clearly described in a methodology that accompanies any reporting. The method should be sufficiently detailed such that the analysis can be independently replicated, and the same results obtained by a competent third party unfamiliar with the monitoring program.

Reports detailing the impacts (if any) on fish and shellfish as a result of a hydrocarbon spill. Reports should contain descriptive statistics of data collected and suitable comparisons between data sets (e.g. ongoing monitoring, reference and baseline data). Reports will document whether the termination criteria have been reached and make recommendations on the requirements of future monitoring.

6 References

Department of Sustainability, Environment, Water, Population and Communities, 2012. Marine bioregional plan for the South-west Marine Region: prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Standards Australia Limited, 1988. AS2542 *Australian standard for sensory analysis of foods. Specific methods.* SAI Global, Sydney.

Underwood, A., 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4: 3–15.

Underwood, A.J., 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42: 569–587.

Appendix C Environmental Sensitivities within EMBA

Appendix C.1 Marine Protected Areas

Protected Area Name	Distance from CHA (km)	Jurisdiction	IUCN Class
Abrolhos Commonwealth Marine Reserve	49	Commonwealth	II – Marine national park zone (2,548 km^2) VI – Habitat protection zone (23,239 km^2) IV – Multiple use zone (56,612 km^2) VI – Special purpose zone (5,727 km^2)
Jurien Bay Marine Park	63	Western Australia	Ia – Sanctuary zones (31 km^2) II – General use / special purpose (778 km^2) VI – Aquaculture / special purpose (14 km^2)
Jurien Commonwealth Marine Reserve	80	Commonwealth	II – Marine national park (31 km^2) IV – Special purpose zone (1,820 km^2)
Abrolhos State Marine Reserve	100	Western Australia	IV – Fish habitat protection area (245 km^2)

Appendix C.2 Key Ecological Features

Key Ecological Feature	Distance from CHA (km)	Description
Ancient coastline between 90 and 120 m depth	63	Consists of a ridge comprised of a submerged shoreline from a glacial period when sea levels were lower. The ancient coastline between 90 and 120 m may host relatively high benthic biodiversity and be associated with increased productivity (Department of Sustainability, Environment, Water, Population and Communities 2012)
Commonwealth marine environment surrounding the Houtman Abrolhos islands	79	The Houtman Abrolhos islands host a unique mix of temperate and tropical species, facilitated by the transport of relatively warm water and tropical larvae southwards by the Leeuwin Current (Department of Sustainability, Environment, Water, Population and Communities 2012). The islands host significant aggregations of breeding seabirds, supporting over one million breeding pairs, and include a range of benthic habitats and associated fisheries resources (Department of Fisheries 2012, Department of Sustainability, Environment, Water, Population and Communities 2012).
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	Overlaps CHA Within EMBA	The west coast inshore lagoons KEF covers ~1,761 km^2 and includes areas that are important for benthic productivity, and breeding and nursery aggregations for many temperate and tropical marine species (McClatchie et al. 2006). The lagoons are dominated by seagrass and epiphytic algae, which provide habitat and food for many marine species (directly and indirectly). Seagrass meadows occur in more sheltered areas and in the inter-reef lagoons along exposed sections of the coast while emergent reefs and small islands create a diverse topography. This mix of sheltered and exposed environments forms a complex mosaic of habitats. The lagoons are also important areas for the recruitment of commercially and recreationally important fishery species, including western rock lobster. Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor and Australian salmon (McClatchie et al. 2006).
Perth Canyon and adjacent shelf break, and other west coast canyons	105 km south-west of CHA Within EMBA	The Perth Canyon is the largest known undersea canyon in Australian waters. Deep ocean currents rise to the surface, creating a nutrient-rich cold-water habitat attracting feeding aggregations of deep-diving mammals, such as pygmy blue whales and large predatory fish that feed on aggregations of small fish, krill and squid (DSEWPAC, 2012)

Key Ecological Feature	Distance from CHA (km)	Description
Western demersal slope and associated fish communities	61 km south-west of CHA Within EMBA	Small pelagic fish are an important component of pelagic ecosystems, providing a trophic link between primary production and higher predators, such as other fish, sharks, seabirds, seals and cetaceans. Fluctuations in abundance of small pelagic fish have serious implications for the functioning of pelagic ecosystems of the SWMR (DSEWPAC, 2012). This species group, which includes 10 species (sardine, scaly mackerel, Australian anchovy, round herring, sandy sprat, blue sprat, jack mackerel, blue or slimy mackerel, red bait and saury).
Western rock lobster	Overlaps CHA Within EMBA	Covers a considerable portion (~40,000 km^2)of continental shelf waters on the lower west coast of Western Australia and was established in recognition of the presumed ecological role played by the western rock lobster (*Panulirus cygnus*) in shelf waters (Department of Sustainability, Environment, Water, Population and Communities 2012, MacArthur et al. 2007).

Appendix C.3 Biologically Important Areas

BIA species	Justification	Description
White shark	Foraging	Overlaps EMBA only
Pygmy blue whale	Migration	Overlaps EMBA only, seasonally present
Humpback whales	Migration & resting	Migration overlaps Operational area and EMBA; resting overlaps EMBA only. Seasonally present.
Australian sea lions	Foraging, haul out sites, breeding sites	Foraging overlaps Operational area and EMBA, haul out and breeding sites overlap EMBA only.
Sea birds (several species)	Foraging	Operational area and EMBA

Appendix C.4 Species of Conservation Significance within EMBA

Common Name	Scientific Name	EPBC Act Status	BC Act Status
Fishes and Invertebrates			
Grey nurse shark	*Carcharius taurus*	Vulnerable	Vulnerable
White shark	*Carcharodon carcharias*	Vulnerable, Migratory	Vulnerable
Oceanic whitetip shark	*Carcharhinus longimanus*	Migratory	N/A
Southern dogfish	*Centrophorus zeehaani*	Conservation Dependent	N/A
Shortfin mako	*Isurus oxyrinchus*	Migratory	N/A
Longfin mako	*Isurus paucus*	Migratory	N/A
Porbeagle shark	*Lamna nasus*	Migratory	N/A
Reef manta ray	*Mobula alfredi*	Migratory	N/A
Giant manta ray	*Mobula birostris*	Migratory	N/A
Freshwater sawfish	*Pristis pristis*	Vulnerable, Migratory	DBCA priority species
Whale shark	*Rhincodon typus*	Vulnerable, Migratory	Other specially protected fauna
Scalloped hammerhead	*Sphyrna lewini*	Conservation Dependent	N/A
Southern bluefin tuna	*Thunnus maccoyii*	Conservation Dependent	N/A
Reptiles			
Loggerhead turtle	*Caretta caretta*	Endangered, Migratory	Endangered
Green turtle	*Chelonia mydas*	Vulnerable, Migratory	Vulnerable
Leatherback turtle	*Dermochelys coriacea*	Endangered, Migratory	Vulnerable
Flatback turtle	*Natator depressus*	Vulnerable, Migratory	Vulnerable

Common Name	Scientific Name	EPBC Act Status	BC Act Status
Marine Mammals			
Long-nosed fur seal	*Arctocephalus forsteri*	N/A	Other specially protected fauna
Antarctic minke whale	*Balaenoptera bonaerensis*	Migratory	N/A
Sei whale	*Balaenoptera borealis*	Vulnerable, Migratory	Endangered
Bryde's whale	*Balaenoptera edeni*	Migratory	N/A
Blue whale	*Balaenoptera musculus*	Endangered, Migratory	Endangered
Southern right whale	*Eubalaena australis*	Endangered, Migratory	Vulnerable
Fin whale	*Balaenoptera physalus*	Vulnerable, Migratory	Endangered
Humpback Whale	*Megaptera novaeangliae*	Migratory	Conservation dependent
Australian Sea Lion	*Neophoca cinerea*	Endangered	Vulnerable
Killer Whale, Orca	*Orcinus orca*	Migratory	N/A
Sperm Whale	*Physeter macrocephalus*	Migratory	Vulnerable
Seabirds and Shorebirds			
Australian Lesser Noddy	*Anous tenuirostris melanops*	Vulnerable	Endangered
Common noddy	*Anous stolidus*	Migratory	Migratory
Fork-tailed swift	*Apus pacificus*	Migratory	Migratory
Southern royal albatross	*Diomedea epomophora*	Vulnerable, Migratory	Vulnerable
Amsterdam albatross	*Diomedea amsterdamensis*	Endangered, Migratory	Critically Endangered
Wandering albatross	*Diomedea exulans (sensu lato)*	Vulnerable, Migratory	Vulnerable
Southern giant petrel	*Macronectes giganteus*	Endangered, Migratory	Migratory
Northern giant petrel	*Macronectes halli*	Vulnerable, Migratory	Migratory
Sooty albatross	*Phoebetria fusca*	Vulnerable, Migratory	Endangered
Soft-plumage petrel	*Pterodroma mollis*	Vulnerable	N/A
Flesh-footed shearwater	*Ardenna carneipes*	Migratory	Vulnerable
Wedge-tailed shearwater	*Ardenna pacifica*	Migratory	Migratory
Bridled tern	*Onychoprion anaethetus*	Migratory	Migratory
Caspian tern	*Hydroprogne caspia*	Migratory	Migratory
Roseate tern	*Sterna dougallii*	Migratory	Migratory
Little tern	*Sternula albifrons*	Migratory	Migratory
Australian painted snipe	*Rostratula australis*	Endangered	Endangered
Osprey	*Pandion haliaetus*	Migratory	Migratory
White-tailed tropicbird	*Phaethon lepturus*	Migratory	Migratory
Australian fairy tern	*Sternula nereis nereis*	Vulnerable	Vulnerable
Indian yellow-nosed albatross	*Thalassarche carteri*	Vulnerable, Migratory	Endangered
Shy albatross	*Thalassarche cauta cauta*	Endangered, Migratory	Vulnerable
White-capped albatross	*Thalassarche cauta steadi*	Vulnerable, Migratory	Vulnerable
Black-browed albatross	*Thalassarche melanophris*	Vulnerable, Migratory	Endangered
Campbell albatross	*Thalassarche melanophris impavida*	Vulnerable, Migratory	Vulnerable
Red knot	*Calidrus canutus*	Endangered, Migratory	Endangered
Curlew sandpiper	*Calidrus ferruginea*	Critically Endangered, Migratory	Critically Endangered
Eastern curlew	*Numenius madagascariensis*	Critically Endangered, Migratory	Critically Endangered
Northern Siberian bar-tailed godwit	*Limosa lapponica menzbieri*	Critically Endangered	Critically Endangered
Bar-tailed godwit	*Limosa lapponica*	Migratory	Migratory

Common Name	Scientific Name	EPBC Act Status	BC Act Status
Common greenshank	*Tringa nebularia*	Migratory	Migratory
Lesser frigatebird	*Fregata ariel*	Migratory	Migratory
Blue petrel	*Halobaena caerulea*	Vulnerable	N/A
Fairy prion	*Pachyptila turtur subantarctica*	Vulnerable	N/A
Greater sand plover	*Charadrius leschenaultii*	Vulnerable, Migratory	Vulnerable

Appendix D Environmental Service Providers

Table 10: Environmental service providers with agreed MoUs in place

Environmental Service Provider
BMT

Table 11: Environmental services for OMP and SMP implementation

		Service Providers			
Service	**Relevant Plans**	**BMT**			
Water quality monitoring	OMP-01, OMP-02, SMP-01	✓			
Sediment quality monitoring	OMP-01, OMP-02, SMP-02	✓			
Spill surveillance (vessel /shoreline / aerial)	OMP-01, OMP-03	✓			
Hydrocarbon trajectory assessment - modelling	OMP-01, OMP-02	✓			
Hydrocarbon fate assessment – modelling	OMP-02	✓			
Marine fauna monitoring (including seabirds, cetaceans, sea lions, turtles and fish)	OMP-04, SMP-05, SMP-06, SMP-07	✓			
Shoreline / intertidal habitat monitoring	SMP-03	✓			
Benthic habitat monitoring	SMP-03, SMP-04	✓			
Sensory analysis for hydrocarbon taint	SMP-07	✓			
Data management	All plans	✓			